Electrical Engineering

April
1932

North Eastern District Meeting—Providence, R. I.—May 4-7, 1932

Published Monthly by the
American Institute of Electrical Engineers

Future Meetings of the American Institute of Electrical Engineers

Place	Date	Nature	Manuscript Closing Date
Providence, R. I.	May 4-7, 1932	District Meeting	(Closed)
Cleveland, Ohio	June 20-24, 1932	Summer Convention	(Closed)
Vancouver, B. C.	Aug. 30-Sept. 2, 1932	Pacific Coast Convention	May 30, 1932
Baltimore, Md.	October 10-13, 1932	District Meeting	July 10, 1932
Memphis, Tenn.	November, 1932 (CANCELLED)	District Meeting	CANCELLED

NOTE: Members who are contemplating submitting papers for presentation at any of the above meetings should communicate promptly with Institute headquarters, 33 West 39th Street, New York, N. Y., so that such papers may be docketed for consideration by the technical program committee, which formulates programs for all meetings several months in advance. Upon receipt of this notification, Institute headquarters will mail to each prospective author important and helpful information explaining the Institute's rules relating to the preparation of manuscript and illustrations.

Future Meetings of Other Technical Organizations

Society and Nature of Meeting	Place	Date	Correspondent
American Assn. for the Advancement of Science	Syracuse, N. Y.	June 20–25	A. L. Elder, Syracuse Univ., Syracuse, N. Y.
American Physical Society	Washington, D. C.	April 28–30	W. L. Severinghaus, Columbia Univ., New York, N. Y.
American Society of Civil Engineers	Yellowstone National Park	July 6–9	G. T. Seabury, Secy., 29 West 39th St., New York, N. Y.
American Society for Testing Materials	Atlantic City	June 20–24	Am. Soc. for Test. Mtls , Phila., Pa.
American Waterworks Association	Memphis, Tenn.	May 2–6	B. C. Little, Secy., 29 W. 39th St., New York, N. Y.
American Welding Society	New York, N. Y.	April 27–29	Miss M. M. Kelly, Secy., 29 West 39th St., New York, N. Y.
Electrochemical Society	Baltimore, Md.	April 20–23	C. G. Fink, Columbia Univ., New York, N. Y.
N.E.L.A. annual convention and exhibit	Atlantic City, N. J.	June 6–10	A. J. Marshall, 420 Lexington Ave., New York, N. Y.
N.E.L.A. Southeastern Division	Old Point Comfort, Va.	April 20–22	C. M. Kilian, 508 Haas-Howell Bldg., Atlanta, Ga.
N.E.L.A. Southwestern Division	Hot Springs, Ark.	April 25–28	S. J. Ballinger, San Antonio Pub. Serv. Co., San Antonio, Texas
Society of Industrial Engrs., Midwest	St. Louis, Mo.	April 22–23	C. C. Dent, Secy., 205 W. Wacker Dr., Chicago, Ill.
South American Electrotechnical Congress	Buenos Aires, Argentina	July 4–11	R. F. Ascher, Secy., Paseo Colon 185, Buenos Aires, S. A.

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This Month—

Front Cover

Reputedly the only one of its kind in the United States, the marble dome of the Rhode Island Capitol is floodlighted by seven groups totaling 109 projectors, 67 kw. in lamps. Providence is host city to the May meeting of the North Eastern District, and the prominently lighted dome of the Capitol may serve well as a landmark for those motoring in at night.

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News of Institute and Related Activities . . . 268

ELECTROCHEMISTRY represents a fruitful field for the application and utilization of electric power; furthermore it holds many opportunities for the young electrical engineer with some knowledge of chemistry. *p. 238–242*

EDUCATION "after college" has met with surprisingly successful results according to a report issued recently by the chairman of the educational committee of the Institute's Chicago Section. *p. 280–281*

PROPER control of lines interconnecting two electric power systems is a problem in load control rather than frequency. Special equipment has been designed to accomplish this and has been found to operate satisfactorily with frequency control equipment on one of the systems. *p. 256–260*

COMMITTEES already have been appointed and are busy preparing for the coming A.I.E.E. summer convention to be held in Cleveland, Ohio, in June. *p. 275*

THE de Laszlo portrait, for which President Hoover recently sat, was unveiled in the Engineering Societies Building, New York, on February 15. *p. 273*

IF REGISTRATION records are an accurate indication, the district meeting held recently in Milwaukee may be classed as an unqualified success. *p. 270–271*

EXPERIMENTS show that of the total current passing through the body during electric shock, only a small percentage actually passes through the heart. *p. 242–244*

PAPERS presented at the recent A.I.E.E. winter convention were liberally discussed by those attending; as much of this discussion as space permits is presented in summarized form in this issue. *p. 272–279*

MORE than 1,200,000 synchronous electric clocks are said to have been sold in 1930. Tests over a period of several weeks show the maximum deviation of these instruments to be only 44 sec. *p. 228–232*

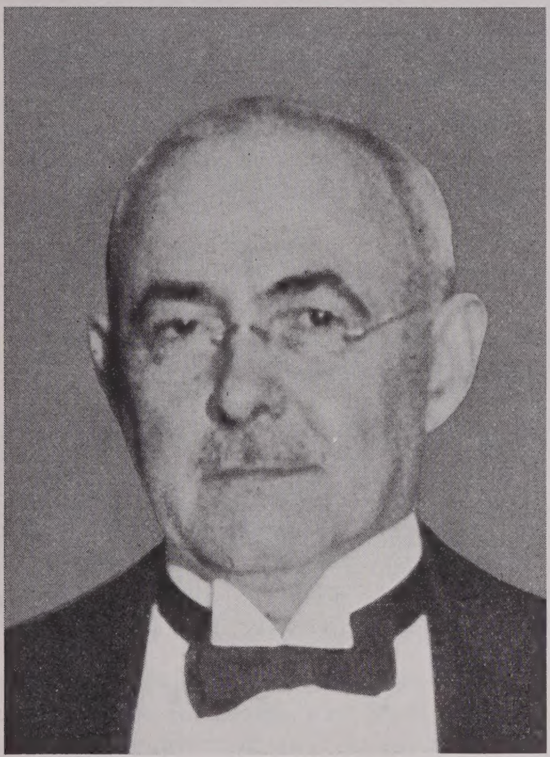
STABILITY studies of metropolitan electric power systems often pave the way for more reliable or economical system layouts. Curves have been developed by which the transient stability may be determined for any system of this type. *p. 232–237*

A RECENT survey shows that 6 per cent of the total railway mileage of the countries of Western Europe are electrified. This percentage is increasing yearly, and despite the present economic crisis 1,042 more route miles now are under construction or authorized. *p. 244–252*

PLANS are practically complete for the Providence meeting of the A.I.E.E. North Eastern District. A well-rounded program with many attractive features has been arranged. (*p. 268–270.*) Interpretive abstracts of all technical papers to be presented appear in this issue. *p. 263–267*

FREDERICK LANE HUTCHINSON

1866—1932



Born at Elizabeth, N. J., April 2, 1866, to Elizabeth (Pring) and John Hutchinson; graduated from Cornell University, 1893; with the Westinghouse Electric & Manufacturing Company from 1893 to 1901; became an Associate of the Institute in 1894; manager of publications for the C. W. Hunt Company of New York, 1901–2; advertising manager for the National Electric Company of Milwaukee, 1902–3; sales manager for the same company, 1903–4; took up special work on the Institute TRANSACTIONS in 1904; appointed Assistant National Secretary in 1908; became National Secretary in 1912; transferred to grade of Member of the Institute, 1913; married Grace Lawrence Duryee of San Diego, Calif., June 27, 1921; represented the Institute at the World Power Conference, London 1924, and at the World Engineering Congress, Tokyo, 1929; died Friday, February 26, 1932.

A MEMORIAL RESOLUTION, adopted by the Executive Committee of the American Institute of Electrical Engineers——

WHEREAS: The death of Frederick L. Hutchinson has removed from the American Institute of Electrical Engineers one of its most devoted members and a leader of marked ability and high ideals,

WHEREAS: During his service of twenty-eight years as a member of the staff, including twenty years as national secretary, he worked unceasingly and effectively for the best interests of the membership and the advancement of the entire engineering profession, exhibiting at all times remarkable enthusiasm, unselfishness, and wisdom,

WHEREAS: His delightful personality, his deep interest in the wide range of activities of the Institute and organizations with which it cooperated, his keen grasp of all questions involved, and his unfailing tact on all occasions, won the respect and admiration of a multitude of friends, be it therefore

RESOLVED: That on behalf of the membership, the executive committee hereby expresses its profound sorrow at the death of one of the Institute's outstanding leaders, and extends to the members of the family of Mr. Hutchinson its deepest sympathy, and be it further

RESOLVED: That these resolutions be inscribed in the minutes of the Executive Committee and a copy be transmitted to the members of Mr. Hutchinson's family.

Synchronous Electric Time Service

Commercial a-c. time service has been made possible by the development of a self-starting synchronous motor and of a master clock to indicate deviations of power system frequency from normal. Construction, accuracy, and application of various types of these devices are described in this article.

By
H. E. WARREN
ASSOCIATE A.I.E.E.

Warren Telechron Co.
Ashland, Mass.

BEFORE the beginning of the present century there were a few individuals who realized the possibility that commercial alternating current, by means of its recurring pulsations, might be used in some manner to measure time; but dreams of this nature did not materialize in practical performance.

Up to 1916 there was no commercial a-c. system in existence in which generator speed was regulated with sufficient accuracy so that the current could be used for the purpose of indicating time by means of synchronous clocks. At that time two devices were brought out which in the succeeding years made possible commercial a-c. time service.

The first of these devices was a self-starting synchronous motor utilizing residual magnetism to permit a rotor to start and run at synchronous speed. This type of motor differs from all the common forms of a-c. motors in that eddy currents induced either in the mass of the rotor or in some form of winding upon the rotor are not utilized to start the rotor from rest. Instead, the rotor is made of such permanent magnetic material and is so proportioned with respect to the field that remanent magnetic poles are set up in the rotor material by the a-c. magnetism of the field in such a manner as to cause the desired motion. Such a motor is sometimes known as a hysteresis motor. Fig. 2 shows a view of a recent model.

The hands of a clock were connected by a gear train with the first of these self-starting synchronous motors and this clock, supplied by current from the local electric light system, was compared with standard time at intervals over a period of several weeks. The new motor driven clock proved to be a very inferior timekeeper, developing daily errors as great as 5 or 10 min., thus proving the need of greater accuracy in the average frequency of the power supply if it were to be used for timekeeping.

Based upon "Synchronous Electric Time Service" (No. 32-40) presented at the A.I.E.E. winter convention, New York, N. Y., Jan. 25–29, 1932.

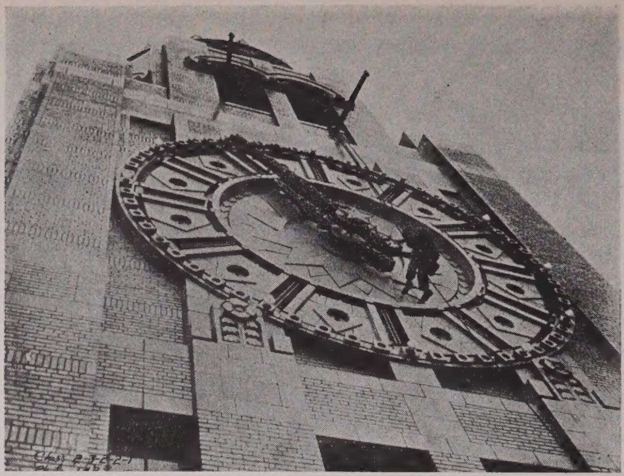


Fig. 1. Dial of a large synchronous tower clock. Illuminated at night, the characters around the circumference flash in succession to indicate seconds

By observing these daily errors it was easy to compute the average value of the system frequency. There are 1,440 min. in a day and the gearing of the clock was such that if the frequency had been exactly 60 cycles, there would have been no time error; a 1 per cent error in average frequency (0.6 cycles at 60 cycles) would mean 1 per cent error in the time of the clock, which amounts to 14.4 min. per day. The actual, computed error in the average frequency as determined by these observations is shown in the upper curve of Fig. 3 which was originally published in the article, "Clocks in the Field of Electric Light Appliances" in the N.E.L.A. *Proc.*, 1917, Commercial Sec., p. 641.

The second device consisted of an indicating instrument that would show to a generating station operator directly in terms of time, deviations of average frequency from standard. Guided by this instrument, an operator could so regulate the speed of his generators as to maintain such small deviations from standard average frequency that the alterations could be used to measure time for all ordinary commercial purposes. Fig. 4 shows the dials of a type of master clock which is in common use. The large dial in the center has two hands, one black and the other gold. The black hand makes a revolution on the dial every 5 min., its rate of motion being regulated by an accurately adjusted pendulum beating seconds. The gold hand is driven by a gear train directly from one of the Telechron self-starting motors. The gear ratio is such that when the average frequency is correct, this hand will also make one revolution in exactly 5 min.

The two hands are started off together, and so long as the average frequency remains correct, will keep together with no visible angle between them. An error in the average frequency will cause the gold hand to move slightly faster or slower than the black hand and they will become separated. The angle of separation will be a direct visible measure of the error in the integrated alternations, which may be conveniently called the system time. If the gold hand is ahead, this will show that the system time is fast; if behind, that it is slow.

An error in the average frequency as small as 1/60 cycle will cause a spread of 1 sec. between the two hands of the master clock in 1 hr. If such an error continues, the spread will continue to increase as time passes. The accuracy of the indication is limited only by the timekeeping precision of the pendulum itself. When carefully regulated this is better than 1 sec. per day, or an absolute precision of about one part in 100,000.

When the operator at the generating station which is regulating frequency adjusts the turbine governors from time to time so as to keep the black and gold hands of the master clock together, he automatically causes all other synchronous motor clocks on the same system to keep correct time. The lower curve of Fig. 3 shows the great improvement in the average frequency value obtained after the first master clock installation.

The standardization of average frequency is of great value to the power companies in the following ways:

1. By improving the service furnished manufacturing establishments, insuring more uniform speed of motor driven machinery and generally assuring the quality of the product.

2. By facilitating interconnection with other power companies which have correspondingly standardized their frequency.

3. By enabling power companies to use synchronous motor movements in their maximum demand meters and graphic recorders, thereby obtaining more accurate and synchronized records at lower cost of maintenance.

Before master clocks were available, the inherent errors in frequency indicators were sufficient to handicap operators on interconnected systems in their efforts to equalize the frequency preparatory to synchronizing the two systems, and to lead to controversy as to the true value of the frequency after the two systems were synchronized.

Master clocks have been adopted generally by the power companies of the United States for the purpose of regulating frequency. At the present time it is estimated that the regulation of the current to over 90 per cent of the consumers' meters in this country is guided by these master clocks.

The accuracy which may be expected at present from a synchronous electric clock is indicated by the records shown on Fig. 5. The records shown on this chart are taken from four typical very large interconnected systems east of the Mississippi River. The ordinates of the curve in each case are seconds deviation from standard time, and the abscissas, weeks over a period of 5 months. The solid line through the center of each curve represents standard time, and the two points plotted for each day at the top and bottom of the band represent the maximum range of the deviations from standard for that day. The widest deviations shown are 44 sec. fast or slow, which means that on these systems a synchronous clock set absolutely accurately with standard time, did not indicate incorrect time more than 44 sec. fast or slow through the period plotted. The records of the two systems which show the smallest departure of standard time indicate that a clock operating on these systems would never be more than 9 sec. fast or slow. There are few uses of time which justify higher accuracy, and even the worst of these records is far superior to that of previous types of commercial clocks.

Some power companies throughout the country may be giving better than the best time service indicated on this chart; probably there are some permitting wider variations. Practically all power companies, however, are giving sufficiently accurate frequency regulation to provide far better time on synchronous clocks than previously available on commercial clocks.

All factors in power system development are tending to require continued improvements in frequency regulation. As a matter of fact the very large interconnected systems have so much momentum stored

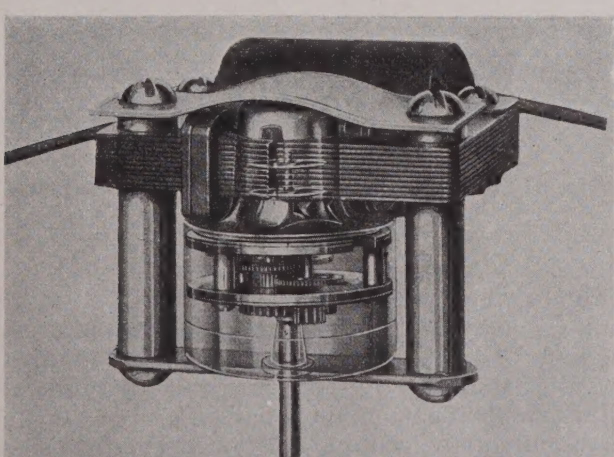


Fig. 2. Self-starting motor and gear train

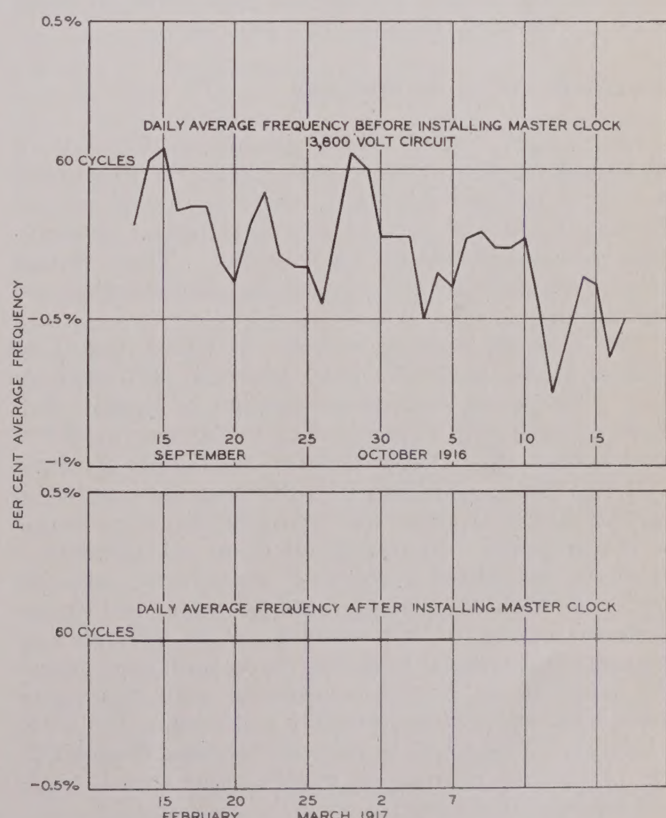


Fig. 3. Daily average frequency before and after the installation of an indicating master clock

in rotating equipment (generators, motors, etc.) that when properly adjusted at the beginning of a flat load period, they will give almost perfect time with no adjustment of governors for speed. Over the irregular portions of the load curve, however, governor adjustment is necessary and much work is being done at present to divide the burden of this

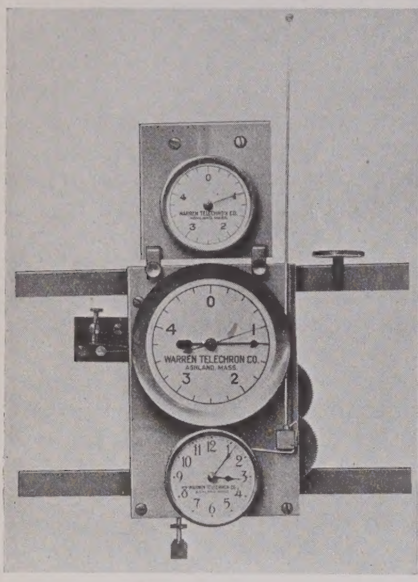


Fig. 4. Operating dials of a common type of master clock

regulation on large interconnected systems between the various power companies by the use of automatic frequency control to supplement the master clocks. When perfected and applied, these instruments will undoubtedly reduce the system time error to insignificant values of the order of 1 or 2 sec.

Synchronous Clock Motors

About 1928, twelve years after alternating current regulated by means of master clocks as illustrated in Fig. 4 became available, there appeared on the market the first of several new varieties of synchronous motors suitable for use in clocks. These motors may be divided into two classes; non-self-starting and self-starting.

The non-self-starting motors, of which there are several kinds, generally have toothed, soft-steel rotors. The usual stator construction is bipolar with teeth on each pole corresponding to the spacing of the rotor poles. In all multi-polar motors of the common varieties the speed is found by dividing the number of current alternations per minute by the number of rotor or stator poles. In nearly all cases no attempt is made to introduce a rotating component into the field. A common arrangement of rotor and stator is shown in Fig. 6. On account of the difference in magnetic reluctance between rotor positions, where the poles do or do not correspond with the stator poles, a strong reactance torque exists when the rotor is at rest. This tends to prevent the rotor from starting; but when running at synchronous speed, tends to keep it at that speed.

It is somewhat difficult to spin such a rotor by hand so as to cause it to lock into synchronism with the alternating field unless some means is provided which will permit a sudden phase shift of the rotor poles as the rotor speed passes through its synchronous value. Among the satisfactory schemes for accomplishing this result is the use of loosely coupled fly-wheels on the rotor shaft or spirally arranged rotor poles with means for the axial shifting of the rotor in the field. Also, when started by hand, mechanical launching devices sometimes are used to bring the rotor up to approximately synchronous speed automatically.

The self-starting synchronous clock motors which have appeared within the last few years utilize a-c. fields with rotating components brought about by the use of shading coils. Most of these motors have multi-polar rotors with some form of squirrel-cage winding or a copper element wherein Foucault currents are induced by the rotating field. Like ordinary induction motors, such motors get their starting torque through the reaction of the Foucault currents in the field. Synchronous driving torque in these varieties of self-starting motors is produced by polar projections of the steel rotors or by a separate polar element loosely coupled to the rotor shaft. One variety of the recent self-starting synchronous motors utilizes remanent magnetism for starting and for synchronous operation.

Any of the rotors described heretofore may be used to drive the hands of a clock through a simple train of gears. Two forms of such gear trains are in common use, one composed entirely of spur gears and the other utilizing worm gears and worms. On account of the greater efficiency of transmission, a spur gear train is better for large clocks, but for small clocks the other mechanism is satisfactory. Frequently the high-speed gears of a spur gear train are made of non-metallic material so as to run more quietly, and the

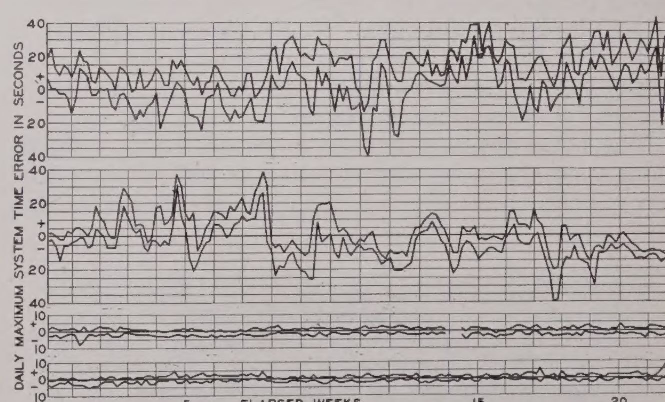


Fig. 5. Maximum daily system time errors of four large power systems

motor or the whole clock movement is usually mounted on cushioning material so as to reduce the a-c. hum. Some clocks are much quieter than others, depending upon the rigidity of the field laminations and the design of the moving parts.

Any one of the motors mentioned is adequate to drive the hands of a clock dial 12 in. or less in diameter. The actual output required for this purpose is

exceedingly small. If the clock hands are balanced and the gear train is fairly efficient, not more than one twenty-millionth of a horsepower is needed for a 12-in. dial. The power output of the various motors ranges from less than one-millionth of a horsepower to more than one-ten thousandth of a horsepower. The larger amount has been found adequate to drive tower clocks 10 or 12 ft. in diameter. The power output of these motors seems exceedingly small as compared with commercial motors used for other purposes; nevertheless it is, fully adequate for this timekeeping duty, and is many times greater than the power of ordinary spring clock motors.

The electric input to these motors is generally in the neighborhood of 2 watts, but as the power factor is low, the voltamperes vary from three to six. Obviously the efficiency of these motors is very low indeed, amounting to a fraction of 1 per cent. However, the power used is so little (17 kw-hr. per year or approximately $1.00 worth) that this feature is of minor importance.

Most synchronous motor clocks are provided with some form of indicator visible through a small hole in the dial. In clocks which are not self-starting this indicator, by its continuous motion shows that the clock is in operation. After an interruption in the current, the motion of the indicator stops permanently. In self-starting motor clocks of the Telechron brand, the indicator back of the dial shows a steady white target as long as the current flows. This target changes to red and remains so after an interruption in the current supply, although the clock of course starts and continues to run as soon as the power is restored.

Inasmuch as most kinds of synchronous motor clocks either will stop permanently or show errors after current interruptions, it is reassuring to know that system interruptions are rare in our thickly settled districts. Often these clocks continue to show correct time within a very few seconds for many months, even for years. In order to provide against the rare stopping of the hands because of interruptions, clocks have been available for many years which have auxiliary spring movements. These movements appeared more necessary in the beginning before a-c. service had become as reliable as it is today.

The successful operation of synchronous motor clocks is quite independent of certain influences which are detrimental to other clocks, such as level position, vibration, and ordinary temperature variations. Extreme temperatures near zero fahr. will stop some kinds of clock motors, but other varieties will operate well below zero.

Applications

Application of these small clock type synchronous motors to many devices and instruments has been going on ever since these motors became available. The first users were the power companies themselves who had many instruments and meters, especially those of the maximum demand type which required timekeeping elements. The spring clocks used for these purposes were inaccurate, troublesome, and costly to maintain. This was especially true because they needed frequent winding and often were located at distant points. The instrument load was sometimes too great for a spring clock to handle with accuracy. As soon as the motors were substituted for the spring clocks there was a great gain in accuracy and reliability and the costly winding was eliminated. It then became possible to redesign the instruments so as to give still better performance.

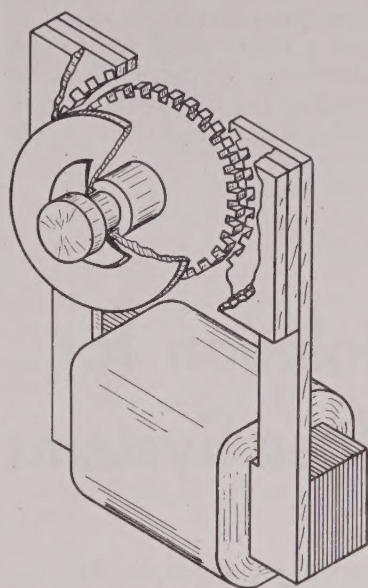


Fig. 6. One type of non-self-starting synchronous clock motor

Gradually nearly all the makers of instruments began using synchronous motors in place of spring movements, until now the list of such motor driven instruments is nearly a complete catalog of devices in which the measurement of time is involved. The largest class of these motor driven instruments is perhaps the graphic recording type. The load of driving a paper chart, especially of the strip type, is very great for a spring clock but comparatively trifling for a synchronous motor. Moreover, the motor can handle a roll of paper so as to make a continuous record for weeks or months without regard to winding. There are also many kinds of instruments which do not make a record but serve to control or actuate, and synchronous motors have been incorporated advantageously into certain forms such as time switches, temperature controllers, traffic signals, etc.

There is a large and important class of timing devices exclusive of ordinary clocks. Among them are numerous kinds of time and cost recorders, program machines, time stamps, etc., wherein synchronous motors have gradually been replacing spring clock movements. In many cases this change has made it possible to eliminate local master clocks, batteries, and expensive wiring.

In building installations, where synchronous clocks, or timing devices driven by synchronous clock motors are numerous it is usual for the customer to provide a so-called "resetting device" or a duplicate source of a-c. energy to guard against the effect of interruptions in the supply of current. In all such installations a separate wiring system is used, connected with the public service system through a suitable switchboard.

The resetting device automatically measures the duration of an interruption and after the current is restored, applies higher frequency or otherwise speeds up the clocks until again they are correct.

The problem of driving very large tower clocks by means of self-starting synchronous motors is much less difficult than that formerly involved in the use of conventional pendulum tower clock movements. Of course it is necessary for the gears and shafts to be very strong because the stresses due to the great weight of the hands and the pressure of the wind are rather high. Fig. 1 shows a tower clock movement installed on the Williamsburgh Savings Bank at Brooklyn, N. Y., where each of the four dials is 26 ft. in diameter and the hands alone weigh 700 lb. per pair. The hour hand sleeves of this clock are of steel and their outside diameter is 4 in. The power required to drive these hands during a heavy wind is less than 0.001 hp. The motors used have a very large surplus power margin.

Since their conception in 1916 synchronous motor clocks and timing devices have increased in use with extraordinary rapidity, especially during the last few years. According to estimates more than 1,200,000 synchronous motor clocks were sold during 1930. There seems little doubt that during the coming years spring and weight driven clocks will be replaced in large measure by the new a-c. timekeepers, which have proved superior in every important respect.

Stability Solution for Metropolitan Systems

By

S. B. GRISCOM, MEMBER A.I.E.E.

W. A. LEWIS, ASSOCIATE A.I.E.E.

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General stability curves are given in this article by means of which the transient stability during fault may be determined for any metropolitan type system. The results are obtained as the permissible fault duration in terms of certain indexes of the system and fault. For a given fault only three readings, taken on a d-c. calculating board, are required, the solution being obtained without the necessity of investigating the electromechanical oscillations.

STABILITY studies of metropolitan type systems may be profitable not because instability has been a serious operating problem, but because such studies often may permit a more reliable or more economical system layout to be utilized safely. Transient stability, that is, stability during faults, has been found to be the limiting condition for stability of metropolitan type systems, all available information indicating that static instability is never experienced in normal operation of this type of system. Under fault conditions the measure of the degree of stability is the time a fault may be permitted to remain on the system without causing one or more generators to lose synchronism. Curves are presented here which permit the ready determination of the permissible fault duration in terms of certain system constants.

These constants may be found for most metropolitan systems from a short-circuit study on a conventional d-c. calculating board. The fundamental premise underlying this method is that setups giving the same values of the system constants or indexes will have approximately the same degree of stability. The curves give the results of studies on hypothetical systems covering the range of the system constants encountered in metropolitan systems. To render this method practical, the number of indexes must be reduced to a minimum. This means that the variations produced by minor influences must be neglected and average values assumed for machine characteristics. It was found that if the scope were restricted to metropolitan type systems, the number of essential indexes could be reduced to three, with means of modifying these three to provide for the variations produced by the more important influences.

In this discussion a metropolitan type of system is considered to be one in which the principal power sources are generators driven by steam turbines and located relatively close to their load centers, with distribution provided by a large number of moderate voltage circuits. The power supply to most metropolitan districts is of this character, but several large districts receive a major part of their power from distant hydroelectric sources which are quite different in character, and for these, individual studies are required. However, if the hydroelectric generating capacity is one-fourth, or less, of the total,

Based upon "Generalized Stability Solution for Metropolitan Type Systems" (No. 32-26) presented at the A.I.E.E. winter convention, New York, N. Y., Jan. 25–29, 1932.

the stability of the other generating sources for faults in their localities still may be analyzed by the methods presented, without serious error.

Metropolitan type systems as above defined are similar in essential characteristics, making generalized studies practicable. The principal features of similarity are as follows:

1. With equal per cent loadings the internal voltages of all generators on the system are practically in phase.

2. Because of the multiplicity of circuits the reactance of the connecting ties holding a generator or group of generators in step with the system does not change appreciably when the fault is cleared.

3. With turbine-generators and short transmission distances, the generator characteristics, no longer being affected by the speed of rotation of the prime mover, line charging current requirements, etc., tend to become fairly uniform in their essential points such as reactances, inertia, and short circuit ratio.

When a fault occurs on a system, all of the generators undergo electromechanical oscillations because of their change in output. Generators which are similarly affected by the fault will react similarly and therefore may be classed as a single unit. In this discussion the term "generator" may indicate either a single machine or a group of machines which react similarly. The most severe faults usually are close to a group of generators and for those cases it is sufficient to consider only two groups of machines, the group most seriously affected or "faulted generator" and the remaining generators.

With the metropolitan type system, the most important factors affecting permissible fault duration are the initial generator output, synchronizing power, and severity of fault. Operation at rated load is the condition usually investigated and this condition has been assumed here, although a factor is introduced to take account of other values of initial load. The remaining two factors may be expressed in various ways, the choice depending upon adequacy and convenience. The index used here for synchronizing power is the over-all reactance between the "faulted generator" and the remaining generators expressed in per cent of the rating of the "faulted generator." The index used for severity of fault is the short-circuit current of the "faulted generator" expressed in number of times rated current, modified if necessary by a factor to take account of fault location.

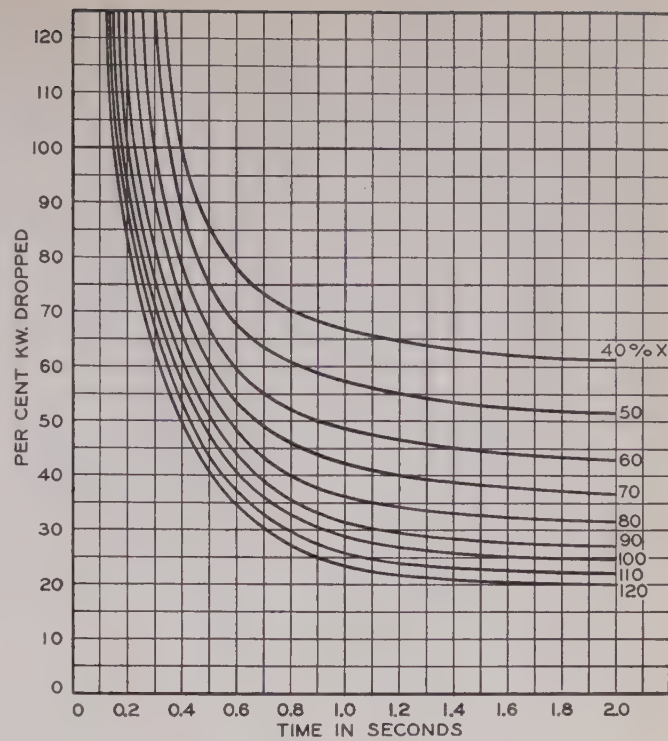

Fig. 2. Auxiliary stability curves. Per cent power dropped versus permissible fault duration

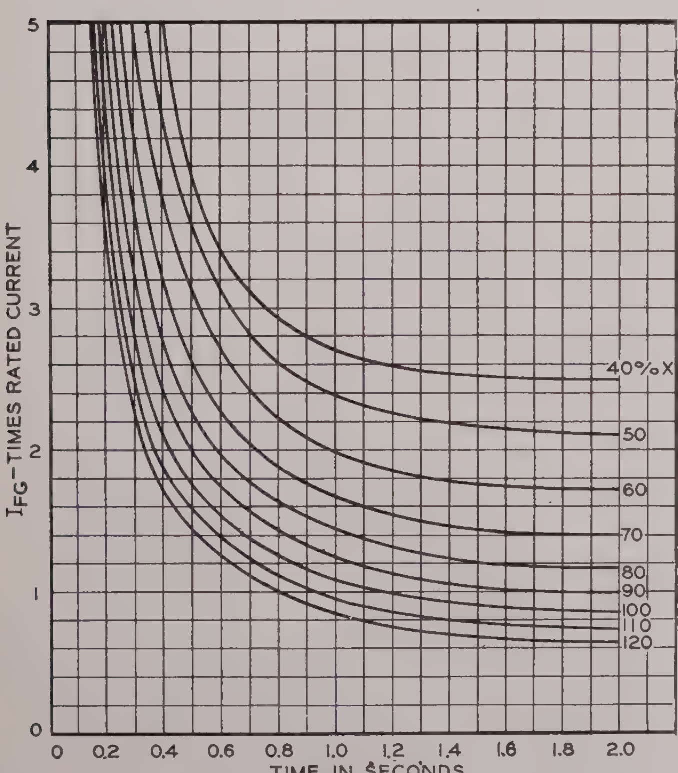

Fig. 1. Principal stability curves. Short circuit current I_{FG} versus permissible fault duration

The general stability curves for a generator short-circuit ratio of 1.0 are shown in Figs. 1, 2, and 3. Other curves, not shown, have been calculated for a generator short-circuit ratio of 0.8. These two sets of curves are very nearly identical, and show that generator short-circuit ratio has a minor effect on transient stability. Fig. 1 consists of a family of curves covering the range of over-all reactance X plotted in terms of short-circuit current I_{FG} from the faulted generator, and the permissible fault duration t. The curves of Fig. 2, as will be shown later, provide a means of correction for resistance in the fault and for other than rated load on the generator.

The curves of Fig. 1 apply directly to faults at locations electrically equivalent to the generator terminals, such as faults on feeders, just beyond the feeder breaker. To provide for faults occurring at other locations, a close approximation is secured by *dividing* the value of I_{FG} by a factor read from Fig. 3 before entering Fig. 1. This "location factor" is obtained as a function of the ratio of I_{FG} to I_F, the total fault current. This ratio will be denoted by r_{FG}.

The application of these curves will be demonstrated by an example. A typical metropolitan type system is shown schematically in Fig. 4 with reactances as indicated. A fault at point M will be considered. A three-phase fault at this location isolates generator A from the remainder of the system for the duration of the fault, and this generator is therefore the one most likely to fall out of step first. Therefore, machine A becomes the "faulted generator," and all other generators including those in the same group with A become the "remaining generators." Fig. 4 under these conditions reduces to Fig. 5. This reduction may be carried out analytically or by the use of the d-c. calculating board. In the latter case the actual reduction to the simplified form need not be completed, as the necessary indexes may be obtained from the current readings necessary for the reduction. From the simplified figure, the over-all reactance X between the faulted generator and the remaining generators is equal to $27 + 15 = 42$ per cent. This reactance must be based on the kva. rating of the faulted generator in all cases, and if the reactances are set up on some other base they must be converted to this base. To determine the total fault current I_F, the branches on each side of the fault are paralleled giving $\frac{27 \times 15}{42} = 9.65$ per cent. The total fault current therefore is $\frac{1}{0.0965} =$ 10.4 times the rating of generator A. The fault current I_{FG} supplied by the faulted generator is $\frac{15}{42} \times 10.4 = 3.7$ times rated current. The ratio of I_{FG}/I_F gives r_{FG} as 0.357. The essential indexes are thus

Over-all reactance X	= 42 per cent
Current from faulted generator I_{FG}	= 3.7 × rating
Ratio $I_{FG}/I_F = r_{FG}$	= 0.357

The location factor is obtained from Fig. 3, entering the curve at $r_{FG} = 0.357$ and interpolating for $X = 42$ per cent, giving a value of 0.7. The adjusted value of I_{FG} is then found to be 3.7 divided by $0.7 = 5.3$. The permissible fault duration now may be read from Fig. 1 for $I_{FG} = 5.3$ (extrapolated) and $X = 42$, and is found to be 0.39 sec.

If the d-c. calculating board is used, the indexes may be found directly. With the system set up without the fault, generator A is connected to the positive bus, its transient reactance being included as part of the system, and the remaining generators connected to the negative bus in a similar manner. The current flowing from generator A now is read and converted to number of times rated current for this generator. For this case the value is found to be 2.38. The reciprocal of this value expressed in per cent is X and of course is 42 per cent as before. The remaining generators now are removed from the negative bus and connected to the positive bus and the fault applied by connecting point M to the negative bus. The fault current and current from generator A then are read and converted to number of times rated current of generator A. This gives the same result as was obtained from the simplified system of Fig. 5, that is, 10.4 and 3.7 times rated current, respectively.

If the fault had occurred at point N outside the feeder reactor on a radial feeder instead of at point M, the simple equivalent system would appear as in Fig. 6. The reactance of the feeder reactor is assumed as 3 per cent on the feeder rating, equivalent to 30 per cent on the rating of generator A, if the feeder rating is one-tenth that of the generator. If the faulted feeder had not been radial and had been tied into the system at the distant end, the equivalent system of Fig. 6 would have been slightly different, although the over-all reactance would still be 42 per cent. It will be found for this case that r_{FG} remains the same since it depends only on the reactance branches adjacent to the generators. Owing to the presence of the 30 per cent reactance in series with the fault, however, the total fault current is greatly reduced and becomes 2.52 times rated current of generator A. I_{FG} is found to be 0.9 times rated current and when adjusted for location becomes 1.29. When these indexes are referred to Fig. 1 it is found that the point is beyond the range of the curves and the permissible fault duration is over 2 sec. Two seconds is about the upper limit of relaying time for most systems and the many variables render it undesirable to carry the curves much beyond this figure.

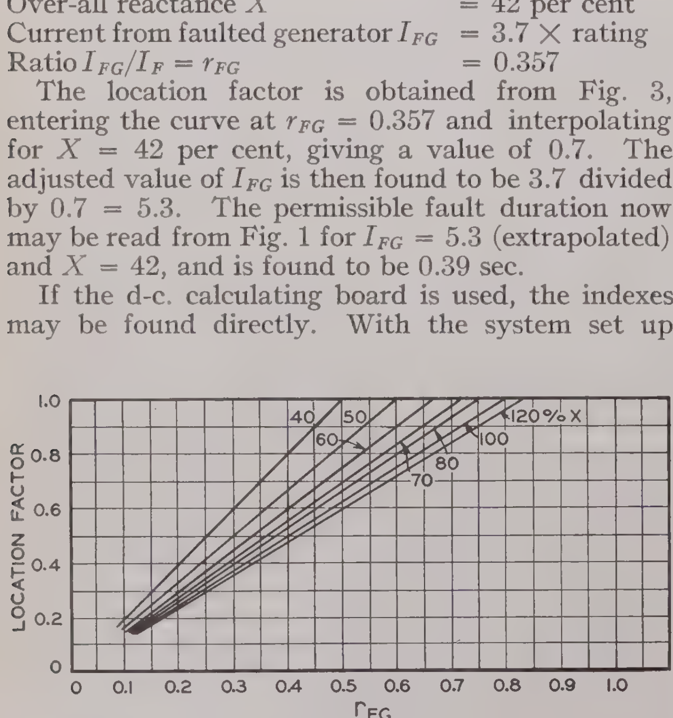

Fig. 3. Location correction factor $r_{FG} = \frac{I_{FG}}{I_F}$

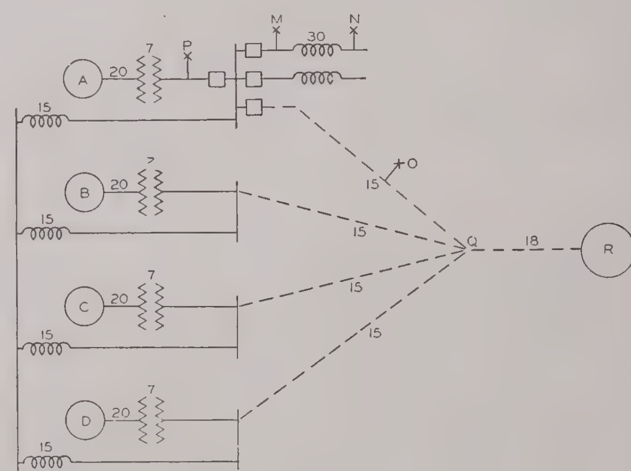

Fig. 4. Typical metropolitan type system

If the fault is at some point O so that it will affect all four of the generators in station A more equally, there is a possibility that this entire group may lose synchronism with the remainder of the system. In such a case, the group should be considered as the faulted generator, and a solution should be carried out expressing all indexes in terms of the rating of the group as a base. This solution should be compared with that for generator A considered as the faulted generator, and the shorter of the two values of permissible fault duration should be taken as the result.

One more variation will be considered, that of a three-phase fault on the leads of the transformer A at point P close to its bus. In this case generator A obviously must be disconnected from the system in order to clear the fault, and the point of interest is how long this fault may persist without causing generators B, C, and D, to lose synchronism with the remainder of the system. Generator A is isolated from the system by the fault while the fault persists, and is isolated by its circuit breaker when the fault is cleared. Therefore, only machines B, C, and D are considered as the faulted generator, and generator A is entirely eliminated from the calculations. The equivalent simplified system for this case is shown by Fig. 7, the reactances now being expressed in per cent on the combined kva. rating of generators B, C, and D. From this point the calculations proceed in the same manner as for the previous examples, leading to $X = 94.1$, $r_{FG} = 0.632$ and the adjusted value of $I_{FG} = 1.80$. This gives 0.53 sec. as the permissible fault duration.

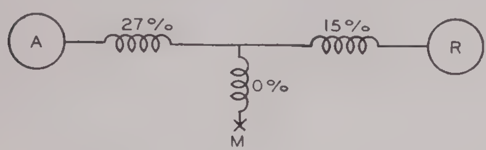

Fig. 5. Simplified equivalent of Fig. 4 for fault at *M*

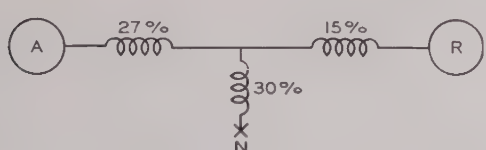

Fig. 6. Simplified equivalent of Fig. 4 for fault at *N*

If the fault had occurred on the bus, the conditions during the fault would have been the same, but after the fault the tie between the synchronizing bus through the bus of generator A to the point Q is interrupted. This violates the fundamental assumption that the reactance after the fault is essentially the same as before the fault, so that the curves cannot be applied with the same degree of accuracy.

Unbalanced Faults

The preceding analysis applies directly to three-phase faults. In many cases, however, investigations of unbalanced faults are of interest. The method of symmetrical components shows that from the stability standpoint an unbalanced fault may be represented by an equivalent impedance in series with the fault, the value of this impedance being a function of the negative and zero sequence impedances of the system viewed from the point of fault. These impedances may be found by reducing the negative and zero sequence network either analytically or on a calculating board.

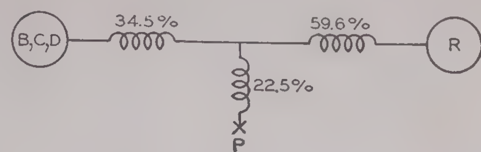

Fig. 7. Simplified equivalent of Fig. 4 for fault at *P*

Correction Factors

The following influences were not considered in setting up the curves of Figs. 1, 2, and 3:

1. Resistance in the connecting lines and in the fault.
2. Values of initial generator load other than normal rating.
3. Voltage regulators.
4. Systems not capable of reasonably accurate representation by two composite generators.

The correction to take these effects into account in all cases shows that the permissible fault duration is as great or greater than would be indicated if the factors were neglected. It is felt therefore that the curves of Figs. 1, 2, and 3 can be used directly without any correction factor for most work. This view is held because for most purposes the limiting cases form the basis of design. A fault of zero resistance and operation at full load give the greatest generator acceleration and therefore lowest indicated stability. Where systems do not reduce to two composite generators, the stability will be as high or higher than when they do. Voltage regulators of course increase the stability. Therefore if the curves are used directly, without correction factors, the error will be on the safe side. It is appreciated, however, that in some cases the effect of these variations on stability is of interest in system planning and operations, and approximate corrections have been set up to take care of these cases. Each of these variations has been investigated analytically, and in some cases extensive calculations were necessary to determine their effect on stability. However, since it was considered most important that the correction factors be easily applied, some liberty in accuracy was taken in formulating a method of applying the corrections. It should be understood therefore that the correction factors now to be described differ somewhat from the theoretically correct values. They are arranged approximately in the order of their importance. Correction factors affecting the value of I_{FG}, if used should of course be applied first.

Resistance

Resistances of the ordinary range have a minor effect on stability, with the exception of resistance in

the fault circuit; that is, those branches carrying the greatest proportion of fault current. Due to the large currents in the fault circuit, a relatively small amount of resistance will result in a considerable power loss. This power loss compensates in a large measure the drop in load on the faulted generator due to drop in voltage, so that the tendency to pull out of step is minimized. Both Figs. 1 and 2 are plotted for faults at the generator terminals. Application of the location factor from Fig. 3 converts a fault at any other location to its equivalent fault at the generator terminals. For each point in Fig. 1 there is a corresponding point in Fig. 2, from which may be found the amount of power required to be dropped by the faulted generator for the equivalent fault at its terminals. If the amount of power dropped is reduced by the presence of resistance in the lines or fault, the effect would be nearly the same regardless of fault location. Hence the result may be found by reducing the equivalent amount of power dropped by the amount of the resistance losses taken by the faulted generator, and reading the corrected value of fault duration from the proper reactance curve of Fig. 2.

In the example previously considered for a fault at M with $I_{FG} = 5.3$ and $X = 42$, a clearing time of 0.39 sec. is indicated by Fig. 1. The same clearing time must be indicated by Fig. 2, hence, for $X = 42$ and $t = 0.39$, it is found that 100 per cent power would have to be dropped by the generator during the fault if the fault were at its terminals. The curves have been drawn by plotting this power as per cent of the generator kw. rating, which is 85 per cent of the kva. rating. Now suppose generator A and its transformer have a total resistance of 1.5 per cent on their rating; with 3.7 times full load fault current flowing, the I^2R loss in the generator and transformer is $3.7^2 \times 1.5$ per cent or 20.5 per cent of the generator kva. rating, or 20.5 per cent divided by $0.85 = 24$ per cent of its kw. rating. Then instead of the 100 per cent load dropped if the generator and transformer had zero resistance, the equivalent load dropped is 100 per cent minus 24 per cent or 76 per cent. The permissible fault duration, considering the effect of resistance, is then found from Fig. 2 for $X = 42$ per cent, and power = 76 per cent, and indicates a permissible fault duration of 0.6 sec.

In the example given above, the resistance in only the generator branch of the equivalent circuit was considered. The power loss was then easily determined, and was all supplied by the faulted generator. If the fault is located at some point on the system where there is a number of paths in multiple for the flow of fault current, the power loss may be determined by adding the I^2R loss in the various branches between the fault and the generator. The currents in the branches may be obtained by measurement of current in corresponding branches of the d-c. calculating board. They may then be squared and multiplied by the per cent resistance of the branches, and added to get the total power loss due to the fault.

If resistance in the fault itself is to be considered, the power loss in the fault must be apportioned between the faulted generator and the remaining generators. An approximate method of doing this is to multiply the total loss in the fault by the ratio r_{FG}, and add this value to the loss in the generator branch of the fault circuit, if this is considered. As an example, for a fault at M assume $^1/_2$ per cent resistance in the arc of the fault, in addition to the resistance of the generator and transformer. With 10.4 times normal current, $10.4^2 \times 0.5$ or 54 per cent of generator kva. in power is created in the arc. This is equivalent to 54 per cent divided by 0.85 or 63.5 per cent of generator kw. rating. Multiplying by r_{FG}, 63.5 per cent $\times$ 0.357 = 22.5 per cent power in the fault, taken by the faulted generator. The power dropped is 100 per cent for $X = 42$ per cent, and $t = 0.39$ sec. When 24 per cent due to generator and transformer resistance and 22.5 per cent due to fault resistance are subtracted, 53.5 per cent remains as the equivalent power dropped. This value of power dropped is seen from Fig. 2 to give a permissible clearing time in excess of 2 sec.

Initial Generator Load

For values of initial generator load other than 100 per cent of kilowatt rating, first find the value of kilowatts dropped, corresponding to X and t for rated initial load. Multiply this by the ratio of initial load to full load, and read the corrected clearing time from Fig. 2, for the curve corresponding to X. Example: with $X = 42$ per cent, $t = 0.39$ sec., 100 per cent kw. is dropped; if the initial load had been 75 per cent instead of 100 per cent, the approximate fault duration may be read as $t = 0.61$ for kw. dropped = 100 per cent $\times$ 0.75 = 75 per cent and $X = 42$ per cent.

Voltage Regulators

Voltage regulators with a moderate rate of excitation response will give a certain amount of improvement in stability over the values given by Figs. 1, 2, and 3. The precise amount is difficult to determine, but from calculations made, assuming a rate of response sufficient to maintain constant flux in the generator field, a reasonable idea of possible improvement may be obtained. The results of these calculations when compared with the standard curves without voltage regulators show that over most of the range the improvement can be approximated by multiplying the value of I_{FG} by 0.85 before entering the curves of Fig. 1.

Different Types of Systems

The curves of Figs. 1, 2, and 3 theoretically are applicable only to systems connected essentially in star form, typified by the synchronized at the load method of connection. This is because the simplified systems which were analyzed in obtaining these curves were of the star form. However, analyses were made also of the ring connection, which represents the maximum possible deviation from the star connection, and the results of these analyses did not differ very greatly from those of the corresponding star systems. Hence, although certain variations will

occur in special cases, no correction factor to take account of system connection is required for most work.

General Comments

The results obtained from these curves, as is to be expected, will have the same order of accuracy as results obtained by a specific analysis of the actual system using the assumptions conventionally made to simplify the work. Further, experience and test have shown that actual systems have greater stability than the usual calculations indicate. This fact should be borne in mind when using the curves for relay settings or system design, and in general, no additional margins of safety need be allowed.

The greatest value of these curves probably lies in the facility with which they allow comparative studies of different layouts to be made. When used in this way the margins between actual and calculated values of stability are largely compensating and therefore need be of little concern except in extreme cases. Sufficient knowledge concerning load and machine characteristics, particularly those factors affecting damping, is not available at present to determine the margins with precision even as a result of the most careful and involved calculations, so that the curves presented here may be used in all cases where they apply until further data have been obtained on hitherto unevaluated factors.

Engineering Lights the Darkness

Shall mind or matter be fostered? In either case, engineering is lighting the path and will continue to light the way of the coming generation. This is the ninth article of the Engineering Foundation's symposium "Has Man Benefited by Engineering Progress?"

By
A. P. GREENSFELDER President, Associated Genl. Contractors of America

DARKNESS is of two kinds: physical the absence of light, and mental the absence of knowledge. Engineering multiplies the means for the earlier relief of both varieties. To create these means is one of the functions of the engineer.

Turning night into day at first seemed sacrilegious. Other steps in scientific and engineering progress have shocked or scandalized many persons in the years that have gone, but they have come to be accepted matters of course. With the discovery of fire came the consciousness that human eyes could see in the firelight as well as in the moonlight. The history of illumination is truly romantic, the firebrand, the torch, animal oil, the candle, mineral oil lamps, gas, and successive steps in electrical illumination marking the accelerating steps in better lighting. Now, television causes no more violent agitation than a few ripples of public interest.

How has man utilized the lengthened day? First, to dispel the fears lurking in the darkness; next to light his path of travel; and then to permit recording and reading current historical events and accentuating religious ceremonies; later, to foster amusement after the hard day's hunting, tilling of the soil, or the fighting of battles; and finally, to extend the opportunities for education, commerce, and social intercourse.

The discovery of window glass changed the design of structures for man's habitation. Sunlight, by penetrating interiors, dispelled dampness and disease. The modern lighthouse and the city's show windows are wonderful combinations of glass and artificial lighting; one promotes safety at sea, and the other adds to the attractiveness of marts of trade. Speed of night transportation depends absolutely upon the engineering application of light; locomotive, vessel, and automobile headlights, signal systems, and the illumination of highways and airports are all vital necessities.

Modern buildings now go to two extremes, walls of glass and windowless walls. Conservation of daylight and complete control of illumination by exact diffusion of electric light both have their places. The "great white ways" of our cities are just signs of our times. Steam turbine power stations, hydroelectric plants, interconnected transmission lines, all bespeak engineering achievements.

Intelligence

The dispelling of mental darkness is even more vital to "life, liberty, and the pursuit of happiness" than is the conquering of physical darkness. The use of "midnight oil" has produced world leaders. Rubbing the lamp of the fabled genii produced small wonders compared to the modern miracles of man.

Whither our way? Shall we foster mind or matter? Shall we add to the mounting volumes of books or of buildings? How should they be correlated?

We talk today of over-production. We lament

over-expansion of facilities for the production of goods. Then why not more homes and schools and hospitals, and better highways to make them accessible, bridges to span the gaps of time as well as space, the sowing of ideas as well as seeds?

Production is threefold: articles to be consumed, wealth in private structures, and community facilities. Engineering minds constantly are eliminating wastes of production. By steadily improving railroads, highways, and other means for carrying goods, they have brought costs of transportation to amazingly low figures compared with those of pre-railroad days. Now with even greater concentration, engineers should devote energy to reducing wastes of distribution. Engineering methods, properly utilized by business men, should be helpful in reducing the costs of merchandising just as they have been helpful in cutting costs of producing goods, power, and light. Engineers will be found ready to cooperate in solving the problems of merchandising.

Engineering analysis is forecasting the future—lighting the paths which our children will follow. Engineering talent must and will aid in directing the tendencies of the time. Perhaps more schools and fewer smoke-stacks, more fine community edifices and fewer factories, more leisure and more light, are the present needs of our people.

Editor's Note: Pursuant to the invitation of The Engineering Foundation, the editors will be happy to receive comments, criticisms, or discussions pertaining to this or the other articles published in this series.

Electrochemistry and Electrical Engineering

Electrochemical and electrometallurgical industries in the United States are said to consume a considerable percentage of the total annual electric power output for the entire country. The fundamental electrochemical processes are discussed in a general way with typical examples given for each general case.

By
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MEMBER, A.I.E.E.

Bureau of Standards,
Washington, D. C.

IMPORTANCE of electrochemistry and electrometallurgy in the broad field of electrical engineering can be realized best when it is considered that (1) these processes furnish basic materials for manufacturing processes; (2) installed operating capacity of these industries is large and increasing yearly; (3) a vast army of workers is employed in these industries which produce outputs valued at several billions of dollars; and (4) electrochemistry and electrometallurgy present a promising field for future developments. Quoting from the 1930 annual report of the A.I.E.E. committee on electrochemistry and electrometallurgy:

"There are many who feel that the electrical industry is more in need of increased outlet for power than of further small gains in the efficiency of electrical apparatus *per se*, and that the great body of expectant young electrical engineers must look for adequate opportunities for advancement more to the fields of utilization and electrical processes than to the conventional ones (fields) of apparatus and generation."

Before proceeding further with the discussion, definition of the term electrochemistry together with some indication of its breadth may be in order. Electrochemistry in a general way may be defined as that branch of science and technology which deals with reciprocal transformations of chemical and electrical energy. Closely related to electrochemistry is electrothermics, dealing with chemical effects produced by heat from applied electrical energy. Closely related also is electrometallurgy which deals with the application of electrochemistry or electrothermics to the extraction or treatment of metals.

The quantitative relationship between the amount of electricity passing through an electrolytic cell and the chemical effects which are produced is expressed in Faraday's laws of electrochemical action. The year 1933 marks the centenary of this great discovery by Faraday.

Electrochemical processes differ from many other applications of electric power in that a power supply of rather low voltage per unit is required, but at the same time one which is capable of delivering large currents. Because of the large currents required one of the principal problems involved is that of limiting the power loss between the power supply and the point of utilization. The provision of automatic control for electrochemical processes presents another problem with which the engineer engaged in this field is confronted; this of course is complicated also by the high current and low voltages employed. Still another problem arises in the provision of suitable insulation in apparatus for use in wet processes, especially those involving acids, caustic solutions, or fumes.

Use of Electricity for Depositing Metals

One of the principal processes for depositing metals by electricity is that known as electrowinning. In this process metals or compounds are deposited from

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Written especially for Electrical Engineering, and based upon a lecture delivered during the electrochemistry and electrometallurgy session of the A.I.E.E. winter convention, New York, Jan. 28, 1932. *Not published in pamphlet form.*

solutions derived from ores or other materials using insoluble anodes.

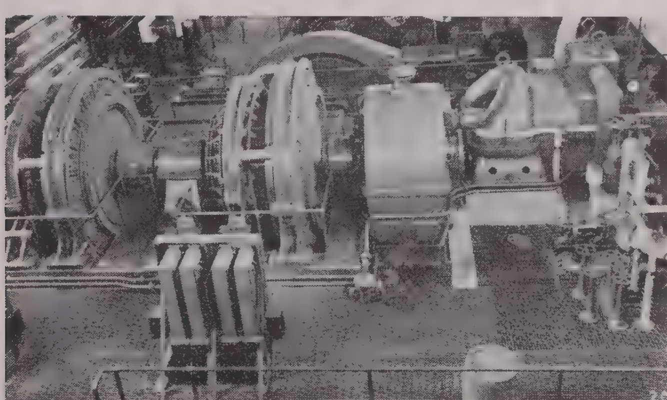
One of the more recent developments of this nature is the electrowinning of zinc. Principal advantages of this method of producing zinc are (1) the higher purity of metal produced (about 99.99 per cent pure), (2) the more complete extraction of the ore, (3) the fact lower grade concentrates are usable, and (4) materials often lost in other processes are recovered. The raw material used is a flotation concentrate of from 19 to 58 per cent zinc. This is subjected to a roasting process to eliminate the combined sulphur dioxide; the resulting calcined product then is leached with sulphuric acid, the solution purified, filtered, and finally electrolyzed by passing a direct current through it. Principal by-products of this process are, sulphuric acid and metallic cadmium. Other by-products which at the present time are lacking a market are germanium, thalium, indium, and gallium.

Besides its application to the production of zinc, the electrowinning process is applied also to the production of other metals, notably copper, and to a less extent lead, tin, nickel, cadmium, and iron.

Electrorefining of Metals

Another deposition process which is of great importance is the electrorefining of metals. This consists essentially of the cathodic deposition of pure metal from the anodic solution of crude metal. The most important commercial process of this type is the electrorefining of copper, the estimated aggregate capacity of eight large plants in the United States being about 3,000,000,000 lb. yearly.

Copper produced from the smelter contains small percentages of other metals, such as gold and silver.



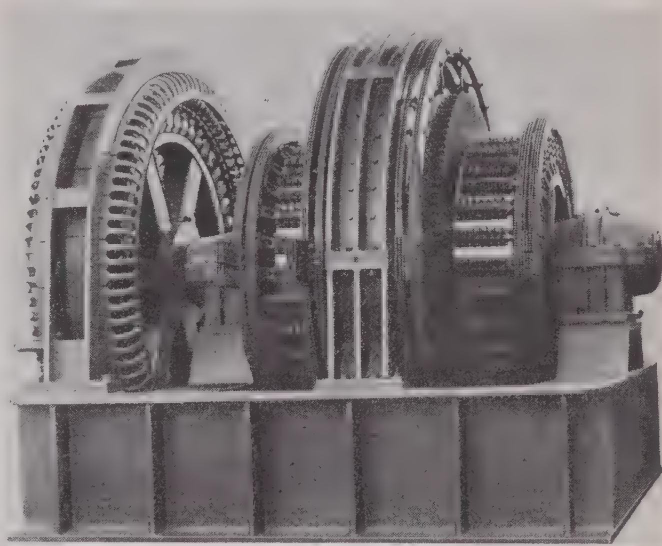
Courtesy of Westinghouse E. & M. Co.

Fig. 1. A pair of d-c. generators driven through a 10/1 reduction gear by a 3,600-r.p.m. steam turbine. Each generator is rated at 11,200 amperes, 140 volts

To produce the exceedingly pure grade of copper required for electrical purposes and at the same time to recover the silver and gold, the smelter product is refined by electrochemical methods. In a typical large plant the operation is carried out as follows:

1. Blister copper obtained from the smelter is first melted and cast into anodes.
2. These anodes are immersed in an acid copper sulphate electrolyte; current passed through the electrolyte deposits the pure copper on the cathode.
3. Cathode copper is melted and cast into commercial shapes.

Current density used in this process (step No. 2) varies from 15 to 25 amperes per sq. ft. of cathode surface. The efficiency of the process is about 95 per



Courtesy of Hanson, Van Winkle, Munning Co.

Fig. 2. Typical motor-generator set used for electroplating. Generator is rated at 10 volts, 25,000 amperes. Note commutator and multiplicity of brushes

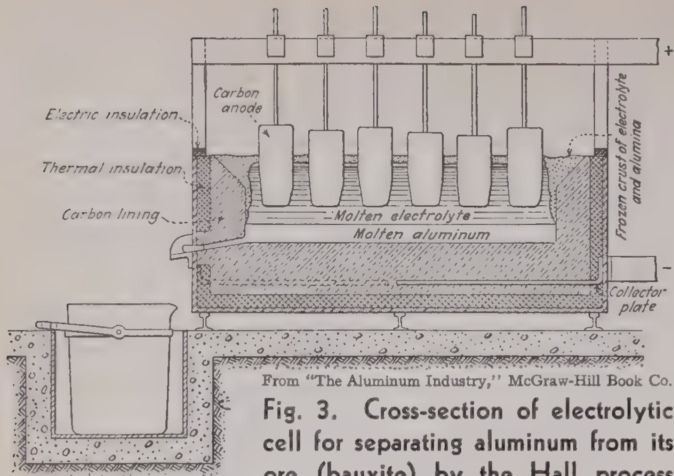
cent, according to Faraday's law. Power supply for this refinery is obtained from turbine-driven generators having a total output of 12,500 kw. at 2,300 volts, 60 cycles. Power is transmitted to the tank house at this voltage where it is converted to low voltage direct current by motor-generator sets. The current passed through each tank is approximately 8,000 amperes, at a d-c. potential of 0.25 volt per tank.

Copper refined by the electrolytic process is characterized by its high purity, 99.98 per cent. Other metals refined electrolytically include antimony, bismuth, gold, iron, lead, nickel, silver, and tin.

Electrolytic refining of metals is a purification process which may be justified even though the per cent gain in purity may appear relatively small. The anode of crude metal may be more than 99 per cent pure but the elimination of a fractional per cent of impurities makes significant changes in physical and chemical properties. In typical cases, the refined metal is softer, has a higher electrical conductivity, is more resistant to some kinds of corrosion.

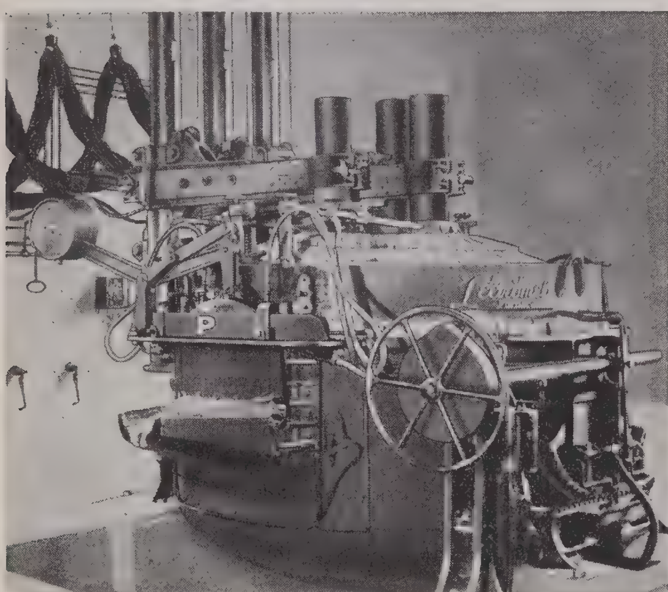
Electroplating and Electroforming

Electroplating is another electrodeposition process of considerable importance. In general, electroplating may be said to be the electrodeposition of an adherent coating upon an electrode for the purpose of



From "The Aluminum Industry," McGraw-Hill Book Co.

Fig. 3. Cross-section of electrolytic cell for separating aluminum from its ore (bauxite) by the Hall process



Courtesy of W. E. Moore & Co.

Fig. 4. A three-phase electric arc furnace having a capacity of three tons per hour

securing a surface with properties or dimensions differing from those of the base metal. The specific object for which plating is carried out may be ornamentation, resistance to wear or corrosion, reflecting power, increased dimensions, or other factors.

Of great interest and importance at the present time is the process of chromium plating. This was accomplished first about 70 years ago, but the past few years have witnessed an intensive development. Principal properties of chromium which are of interest in connection with its use in plating are its extreme hardness, low ductility, resistance to tarnish, and reflecting power, which is about 65 per cent (compared to 95 per cent for silver). For best results the thickness of a chromium coating is usually between 0.00002 and 0.00004 in.; thicker coatings tend to crack and peel. For best results the chromium usually is applied over a preceding metal plating, preferably either copper or nickel.

The bath used in chromium plating is chromic acid with the addition of chromium sulphate or carbonate. For the anodes, lead or iron are used; bath temperature ranges from 40 to 60 deg. cent. In this connection it may be mentioned that the "throwing" power of chromium is relatively poor. By this is meant that the ability of the metal to distribute itself evenly over an uneven cathode surface is less than that of many other metals.

In regard to the power requirements for chromium plating, a bath voltage of from 6 to 12 volts is needed (a rather high figure for plating). The current density required is from 100 to 300 amperes per sq. ft. of cathode surface. The resultant "electrolytic" efficiency is rather low which together with the valence of 6 at which chromium is deposited makes the cost of current for chromium plating rather high, in fact it is about fifteen times that for an equivalent amount of nickel plating, but less chromium generally is used.

Other electroplating processes, some of which are more or less well known, are cadmium, copper, gold, lead, nickel, silver, tin, zinc, some alloys, and even rubber. Recently some success has been attained in electroplating aluminum. Rubber, unlike the metals, is deposited at the anode and not the cathode.

Electroforming is still another type of electrodeposition; this process is used for the production or reproduction of articles. Included in this class of processes are electrotyping; reproduction of engravings, medals, and phonograph matrices; and the making of seamless tubes. The process provides an extremely accurate method of reproducing a metallic surface, and it is said that lines 0.00002 in. wide can be reproduced faithfully. Metals commonly used in these operations are copper, nickel, and chromium.

Electrolysis of Fused Electrolytes

Electrolysis of fused electrolytes is a process employed for the electroseparation of certain metals from ores or compounds in the fused state. One of the most common metals separated from its ore in this manner is aluminum. Although aluminum is the most widely distributed of the metals in nature, its commercial use has become possible only in recent years, largely as a result of the electrochemical process introduced by Hall. This process consists of simply passing a direct current through a molten bath of cryolite (Na_3AlF_6) containing dissolved aluminum oxide (Al_2O_3).

The electrolyzing of the molten bath is carried out in specially designed cells sometimes called electrolytic furnaces or "pots." (See Fig. 3.) For anodes carbon blocks are used, these being mounted in the tops of the cells. Aluminum in liquid form is separated by the action of the current passing through the molten bath, and is deposited in the bottom of the cell on the carbon lining which serves as the cathode. The anodes waste away gradually with the formation of carbon monoxide; the fused aluminum is protected from oxidation, however, by the fused cryolite immediately above it.

In commercial plants usually from 30 to 100 cells are connected in series. The potential required per cell is from 5 to 7 volts, the current requirement being from 8,000 to 30,000 amperes. From 10 to 12 kw-hr.

of electric energy is required per pound of aluminum produced, with a resulting operating efficiency of from 75 to 90 per cent. In this connection it should be noted that the continuity of power service in a plant producing aluminum by this method is quite essential, for if a cell becomes frozen the contents must be dug out, the material is wasted, and the cell must be relined. Purity of the aluminum produced in this manner is about 99.7 per cent.

For aluminum of higher purity, the Hoopes process for refining sometimes is used. This operation is carried on in specially designed cells also, but in this case the anode is at the bottom. Aluminum to be refined is a liquid alloy upon which is molten electrolyte, with the pure cathode aluminum at the top of the cell. The resulting product, which has a purity of better than 98.98 per cent, is relatively soft, possesses high electrical conductivity, and is resistant to corrosion.

Other metals separated from their ores or otherwise treated in the fused state by electrolysis, are magnesium, sodium, calcium, lithium, cerium, and beryllium. Beryllium is a metal lighter than aluminum, is hard and brittle, and is resistant to tarnish, but at present is not widely used.

Electrolysis of Brine and Hydroxide Solutions

Electrolysis of brine and hydroxide solutions is carried out in large electrolytic cells, a direct current being passed through the solutions between suitable electrodes. Some of the more common products of these processes are chlorine, hypochlorites and chlorates, caustics, hydrogen, and oxygen. Alloys of sodium also are produced in this manner in certain types of cells.

Chlorine has many uses, some of the more common being in the paper and textile industries for sanitation purposes, for the manufacture of poisonous gases, and in the formulation of synthetic organic compounds of which carbon tetrachloride is a familiar example. Hydrogen is used in the manufacture of synthetic ammonia, in the hydrogenation of oils, in atomic hydrogen welding, and in other well-known processes.

As regards the economic considerations involved in the production of gases by electrolysis, oxygen produced electrolytically must compete with that obtained by fractional distillation of liquid air. Electolytic hydrogen also competes with that obtained by other methods. There are many ways of producing hydrogen which vary greatly in cost. In most cases, however, low cost of production is offset, at least in part, by the cost of subsequent purification. Hydrogen produced by electrolysis has a purity of from 99.5 to 99.9 per cent, and this is the only method in which purification is not generally necessary. Thus it is obvious that although the cost of producing the gas may be somewhat higher by the electrolytic method, the total cost of the gas when other methods are used, including purification, is such as to make the electrolytic method attractive, particularly if there is a market for the other products of electrolysis that go with it.

In a plant recently described, units of 140 cells each are used, these being connected in series. Current and voltage requirements are respectively 2,500 amperes and 700 volts (5 volts per cell). Each unit produces 5,500 cu. ft. of hydrogen per hour.

Electric Furnaces and Electrometallurgy

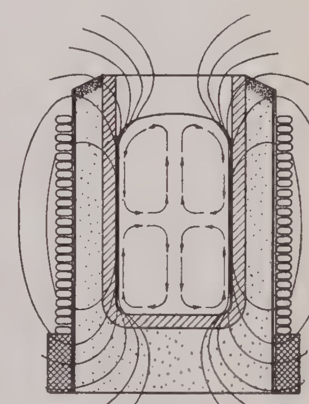
Temperatures higher than those obtainable by combustion methods are required in the manufacture of many electrochemical and electrometallurgical products. In such cases, heating by electricity finds a ready application. In general, electric heating possesses greater flexibility of application than heat obtained from gas or solid fuel combustion. This means that heat produced from electricity usually can be developed at or adjacent to the point of use more rapidly and effectively than when fuel is used, with the further advantage that smoke, ashes, and fumes are absent.

In many electrometallurgical operations heat is applied to the material undergoing treatment in an electric furnace, of which there are various types. The electric furnace, however, is not inherently an efficient device, and special care must be exercised so that the electric energy will be applied properly.

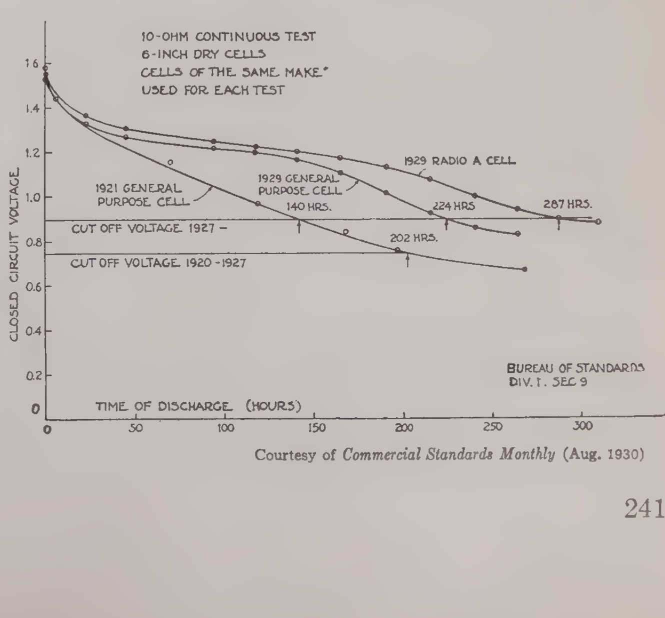
In resistance furnaces heating is accomplished by electric current (either a-c. or d-c.) passing through some resistant material which may be either the reacting substances or a resistor from which heat is imparted to the reacting substances. One of the typical uses for the resistance furnace is in the manufacture of carborundum. In this case the current passes through a core surrounded by silica (SiO_2) and

Fig. 5. (Right) Diagram of induction furnace showing magnetic field and stirring effect produced in the charge by eddy currents

Fig. 6. (Below) Curves illustrating improvement in commercial dry cells; output is shown for same brand of cell in 1921 and 1929



Courtesy of Ajax Electrothermic Corp.



Courtesy of *Commercial Standards Monthly* (Aug. 1930)

carbon. The reaction is such that the silicon and carbon combine to form carborundum (SiC) and carbon monoxide.

Another common type of electric furnace now in use is the arc furnace which is used principally in the iron and steel and ferro-alloy industries. Arc furnaces may be subdivided into two general types: (1) that in which the arc occurs between the electrode and substance undergoing treatment; and (2) that in which the arc occurs between electrodes. Ferro alloys represent an important product of this class of electric furnace. These include not only alloys which are suitable for producing steels having certain definite properties, but also alloys such as ferro silicon and ferro manganese which are used for cleansing and deoxidizing purposes in the manufacture of such steels.

Another important kind of electric furnace is the induction type. These furnaces are used on alternating current only. The first variety of these consists essentially of a transformer with a single short-circuited turn as its low voltage winding, this turn formed by the material undergoing treatment. The second type is known as the high frequency induction furnace, in which eddy currents are induced in the charge or crucible. (See Fig. 5.) These eddy currents produce the heat. Induction furnaces have found their widest application in non-ferrous metallurgy, but recently some of the high frequency furnaces have been used for melting special alloy steels. The size of induction furnaces has been increased recently and high frequency furnaces having a capacity of four tons are now in use.

Batteries

Perhaps the most common electrochemical application to the average electrical engineer is in connection with electric batteries. The well-known dry cell is a common example of primary battery and requires no further introduction. It may be of interest to note, however, that the efforts of research and testing have borne fruit in this field, as well as in others, and have resulted in the production of cells of greatly improved quality. This is brought out in Fig. 6.

Storage cells or accumulators also are familiar to the average electrical engineer and in general need no further description or explanation. They provide a portable source of power, or a dependable reserve source of power, and are applicable in cases where other power sources are lacking, as in farm-lighting plants and in submarines. The weight of storage batteries represents their principal limitation. Theoretically 12 ampere hr. per lb. per cell might be obtainable, but the present practical limitation is about half that figure.

Conclusion

Treatment of the subject matter of this article necessarily has been generalized in nature. That it would be impossible in an article of this length to give any detailed treatment of a subject embracing such a wide field of activity as electrochemistry, is quite obvious. Nevertheless, electrochemical and electrometallurgical operations have been demonstrated to be a fruitful field for the application and utilization of electric power. For this reason alone the subject should be of interest to electrical engineers in general, and especially to the great body of expectant young engineers. Development of new materials and processes, however, based upon the utilization of this power is a field requiring talent of high order; but at the same time it is one which should prove extremely attractive to men of electrical training who can and will superpose upon that training a knowledge of the fundamentals of chemistry.

Heart Injury From Electric Shock

Experiments and observations show that the heart is especially susceptible to injury from electric shock. Using experimental animals, measurements of heart currents showed that about 10 per cent of the total "shock" current actually flowed through that organ.

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Studies of the effects of electric shock upon rats indicated that the injury in most cases was confined to that portion of the body which was traversed by the current. (A.I.E.E. Jl., V. 49, Jan. 1930, p. 25–9; A.I.E.E.Trans., v. 49, 1930, p. 381–94 and v. 50, 1931, p. 1165–70; *Elec. Jl.*, v. 28, 1931, p. 472.) Accordingly a series of experiments was instigated to determine the effect upon the heart, since this organ is believed to be especially susceptible to injury from this source. As the extent of the injury is believed to be proportional to the amount of current flowing, experiments were directed toward determining the actual current flowing

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through the heart when contact with a circuit was made at various parts of the body.

Because the ventricles of a dog's heart are readily thrown into a permanent state of fibrillation by the application of a relatively weak current, as is the case with man, dogs completely anaesthetized with morphia and ether were used in the investigation. By ventricular fibrillation is meant the failure of the ventricles of the heart to beat with a coordinated rhythm; under this condition all individual muscle fibers of the heart contract asynchronously and accordingly no blood is circulated by that organ.

Measuring the Heart Currents

Many interesting features were involved in measuring the current through the heart, but it was somewhat simplified by the fact that as a source an ordinary 60-cycle a-c. circuit was used. After some preliminary experiments, it was decided to measure the current by means of a ring or through type current transformer with the heart itself forming the primary conductor. If made small enough, a device of this kind could be introduced into the chest and surround the heart without seriously disturbing natural conditions. For the cores of these transformers the highest quality magnetic material was used. (The authors wish to take this opportunity to thank the Bell Telephone Laboratories, Inc., and the Westinghouse Electric and Manufacturing Company for their kindness in furnishing the cores.) These cores were ring shaped and had approximately a square cross-section with an area of 0.01 sq. in. These transformers were made up in various sizes from $^5/_8$ in. to 3 in. in diameter, for use with different sizes of hearts as found in different animals.

Each transformer core was thoroughly insulated with varnish, after which the secondary windings, consisting of No. 36 B&S gage silk-covered wire, were wound on by hand, great care being exercised to wind closely and uniformly. Each transformer core was wound with a whole number of layers, with the result of course that different transformers had different numbers of turns, these varying from 1,500 to 2,500. This introduced no difficulty, however, as each transformer was calibrated separately.

In making measurements the terminals of the transformer secondary winding were connected across a potentiometer type rheostat, and the desired portion of potential drop fed into a vacuum tube amplifier; the output of this amplifier was a measure of the current flowing through the heart. Complete details of this electrical equipment are published elsewhere (*Rev. Sci. Instr.*, v. 2, p. 541, 1931).

Operation of these transformers was carefully checked using a conducting bath of sodium chloride solution as the primary or central conductor; the bath was of such dimensions as to insure uniform current density at its center. These tests showed that with the small currents used, the transformer secondary currents in all cases were proportional to the currents actually flowing through the area enclosed by the ring. Therefore, subsequent measurements obtained with the ring enclosing the heart gave direct indications of the amount of current flowing through that organ.

Insertion of the Transformer

The heart is located in the thorax and is enclosed in a membranous sack called a pericardium; the organ lies free in this sack, its only permanent connection being the great blood vessels at its base. To insert the transformer, the thorax was opened under artificial respiration and the pericardium freed from its attachment to the diaphragm; the transformer then was passed over the apex until it fit snugly about the mid-region of the ventricles where it was held in place by ligatures passing through the pericardium. After the transformer was in place the pericardium was sewed closely to its original attachment on the diaphragm, after which the chest was closed, except for a small opening needed to carry out the transformer secondary leads. By closing the chest after insertion of the transformer and maintaining rhythmic mechanical inflation and deflation of the lungs physiological conditions were preserved as carefully as possible. The transformer secondary leads then were connected to the current measuring apparatus, and the electrodes were applied to various parts of the animal's body. The electrode circuit was arranged so that the current could be adjusted as desired.

Results

When the current pathway was from the head to the lower extremities, that is, parallel to the axis of the trunk, from 9 to 10 per cent of the current flowing through the body was found to pass through the heart. A slightly greater percentage of the total current was found to flow through the heart when it entered at the right fore-leg than when it entered at the left fore-leg.

In cases where the current entered at one fore-leg and passed out at the other, the experiments showed that only about 3 per cent of the total current passed through the heart. In these tests the current flow was across the body, and accordingly the transformers were attached to the right side of the heart. No current could be detected flowing through the heart when the current path was from hind-leg to hind-leg. Current distribution throughout the animal's body was found to remain substantially constant for a full half hour after death.

Current required to initiate fibrillation in the heart also was studied in several cases using a 5-sec. shock for each test. The amount of current necessary to produce this condition was found to vary considerably among individual animals as would be expected; the maximum, minimum, and average values observed were, respectively, 15, 6, and 9 milliamperes.

In order to check the accuracy of the results found for different current pathways, several tests were made to determine the amount of current that must be applied at the surface of the body to produce fibrillation, without the ring transformers in place.

Results of these experiments confirmed earlier findings; therefore, only one will be mentioned. In this case, a current of 90 milliamperes, entering at the right fore-leg and leaving at the lower extremities of the animal's body, was required to set the heart in fibrillation. With the current flowing between the animal's two fore-legs, 243 milliamperes were required to produce the same condition.

From the results of these experiments it is evident that a much greater proportion of total current flowing through the body will pass through the heart when the current pathway is from either hand to either foot than when it is from hand to hand. The finding that more current flows through the heart when the current path is from the right side to lower extremities than is the case when the current enters the body at the left side, confirms earlier experimental work with rats.

The authors wish to take this opportunity to acknowledge their appreciation to the committee on physiology of the Conference on Electric Shock for providing funds for this work.

A Review of European Railway Electrification

The development, present status, and future plans of railway electrification in western Europe were studied by the authors during the spring of 1931 on an inspection tour of the more important systems. General findings and part of the data secured are presented here.

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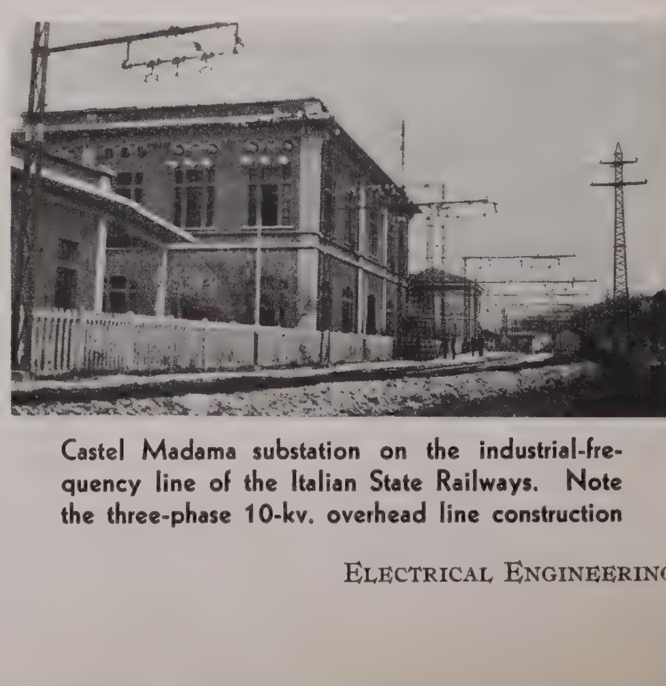
DURING the past 30 years in Europe, as in America, heavy electric traction has evolved from short installations on sections of road difficult to operate with steam to the present heavy traffic high speed projects which find justification economically as well as in the increased use of existing facilities. Although as indicated in Table I the United States leads the world in aggregate miles of electrification as it does in total railway mileage, less than 1 per cent of the mileage in this country is electrified while 6 per cent is the corresponding figure for the western European countries. Despite the present economic crisis, the electrification of 275 route miles was completed recently and 1,042 route miles are now under construction or authorized.

In most of the European countries the standard system of electric traction as indicated in Table II has been adopted by governmental action; in many of the countries other traction systems also are employed to a minor degree. There are four major traction systems in Europe: the single-phase and three-phase a-c. systems, and the 750/1,500-volt and 3,000-volt d-c. systems. The single-phase a-c. systems (mostly 16.7-cycle, 15-kv.) and the d-c. systems (mostly 1,500-volt) are rapidly expanding; the three-phase (16.7-cycle 3,700-volt) system probably will be slowly extended in the present region. Countries using the a-c. and d-c. systems differ in method of power generation; the d-c. systems purchase or generate power at commercial frequency and are connected with the national power networks, often considered of vital importance in selecting a standard traction system. The a-c. systems (with the exception of Sweden) generate almost all of their power at traction frequency with transmission independent of the industrial network.



Castel Madama substation on the industrial-frequency line of the Italian State Railways. Note the three-phase 10-kv. overhead line construction

Written especially for ELECTRICAL ENGINEERING. *Not published in pamphlet form.*

Table I—Mileage and Equipment of European Electrified Railways—End of 1931

Country	Total Railway Mileage	Electrified Mileage: Operated Route	Electrified Mileage: Operated Track	Electrified Mileage: Construction Route	Locomotives: Total	Locomotives: Electric	Cars: Passenger Total	Cars: Passenger Electric	Cars: Freight
Austria	4,153	510	900	78	2,666	168	5,840	7	31,180
France	27,587	1,011	2,230	100	14,643	518	24,460	910	391,660
Germany	36,231	968	2,373	53	24,871	440	65,430	2,000[a]	641,000
Great Britain	20,300	482	1,181	50	22,798	33	71,020	3,058	690,220
Italy	13,560	1,392*	2,500	119	5,862	905[b]	8,590	54	152,410
Netherlands	2,289	117	293	......	1,345	......	5,210	301	35,120
Spain	10,138	410	710	......	......	90	......	110	......
Sweden	10,367	726	1,040	539	1,950	246[b]	4,000	4	50,000
Switzerland	3,365	1,590*	3,000	103	1,356	551[b]	5,320	87	20,200
Total	127,990	7,206	14,227	1,042	......	2,951	......	6,351	......
United States	250,026	2,250	5,200	200	57,174	650	53,020	3,075	2,307,000

a Including 1,500 cars of Berlin suburban service; 800 volt d-c. system.
b Including locomotives on order: Italy, 95; Sweden, 104; Switzerland, 33.
* Not including approx. 600 miles of electrified secondary lines in each country.

Table II—General Means of Traction Energy Supply

Country	Traction System Adopted	Generation: Steam or Hydro	Generation: Frequency	Generation: Ownership	Transmission Ownership	Conversion Method*
Austria	A.C. 1 ph. 16.7 cy. 15 kv.	Hydro	Traction	Railway	Railway	Transf.
France	D.C. 1,500 volts	Hydro	Industrial	Railway	Railway	S.C. & R.
Germany	A.C. 1 ph. 16.7 cyc. 15 kv.	Hyd. & St.	Traction	Ry. & Ind.	Ry. & Ind.	Transf.
Great Britain	D.C. 750/1,500 volts	Steam	Industrial	Ry. & Ind.	Ry. & Ind.	S.C. & R.
Italy	A.C. 3 ph. 3.7 kv., 16.7 cy.	Hydro	Traction	Railway	Railway	Transf.
	D.C. 3,000 volts	Hydro	Industrial	Ry. & Ind.	Ry. & Ind.	M.G. & R.
Netherlands	D.C. 1,500 volts	Steam	Industrial	Gov. & Ind.	Ry. & Ind.	M.G. & R.
Spain	D.C. 1,500 volts	Hydro	Industrial	Industrial	Railway	S.C.
Sweden	A.C. 1 ph. 16.7 cy. 16 kv.	Hydro	Trac. & Ind.	Gov. & Ind.	Ry. & Ind.	M.G.
Switzerland	A.C. 1 ph. 16.7 cy. 15 kv.	Hydro	Traction	Railway	Railway	Transf.

* S.C. = Synchronous converters; R. = Rectifiers; M.G. = Motor-generator units; Transf. = Transformers.

Railways using the d-c. traction system are installing mecury arc rectifiers in preference to synchronous converters or motor-generators. Rectifiers are preferred even when regeneration is important, but since it is not feasible at present to construct rectifiers to handle regeneration, this energy is dissipated in resistances. Steep gradients make regeneration attractive, but few of the countries have utilized this form of braking extensively; rheostatic braking is more commonly used, but to a limited degree. In the opinion of many of the railway administrations the form of draft gear (buffer and screw coupler) does not facilitate a locomotive safely braking the train. The installation of automatic couplers, and of air-brakes on freight equipment, is now under discussion; if carried out, automatic air and control circuits will be included in the coupler, differing from the present American type.

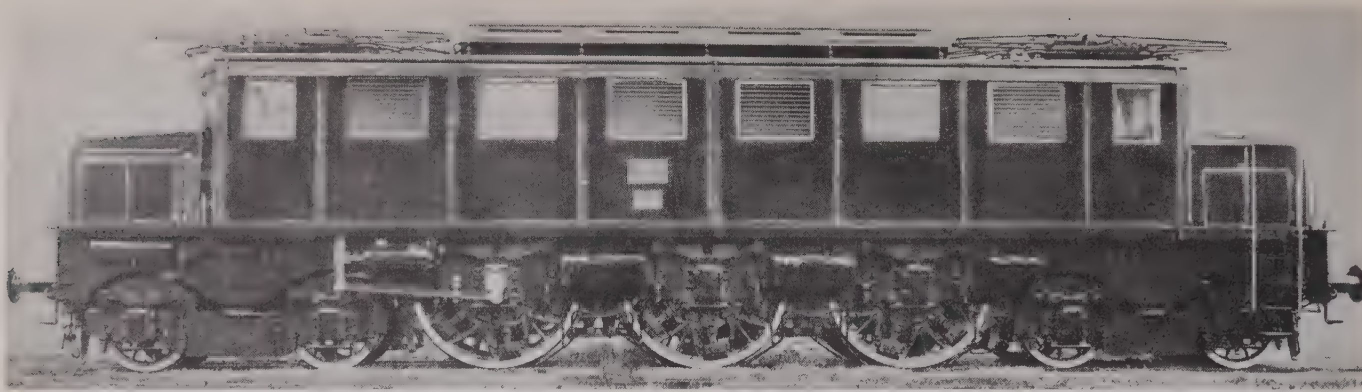
Locomotive construction generally is being standardized so that several manufacturers may supply interchangeable parts built from railway drawings. Similarly the same parts and groups are often adapted for use on various locomotive types. As in the United States, there has recently been a great improvement in the design and construction of the single-phase a-c. commutator motor, and such motors have proved extremely satisfactory. Individual axle drive locomotives generally are built for high speed express and passenger services and the side rod drive for slower services. The intervals between general overhauls vary widely in the different countries and apparently are not greatly influenced by the type of traction system.

Table III—Contact Wire Heights

	Normal Ft.-In.	Minimum Ft.-In.	Maximum Ft.-In.
Austria	—	—	—
France	19—8	15— 1	—
Germany	19—8	14— 9	21—4
Great Britain	16—0	13—10	20—0
Italy	18—1	14— 9	19—8
Netherlands	18—1	15— 9	18—5
Spain	18—1	13—11	20—0
Sweden	18—5	15— 9	20—6
Switzerland	18—1	15— 9	19—8
United States	—	15— 2	25— 0

It is a common practise with motor car equipment to place all electrical apparatus, including resistance grids, in a compartment. Cleanliness, accessibility, and protection from damage are the advantages claimed at the expense of using valuable space and the difficulty of securing adequate ventilation. However, as in America, several European railways have placed this apparatus under the car body and have found this arrangement satisfactory. The use of electric train heating has made it necessary to standardize on the type of heaters and jumpers independent of the traction systems, as passenger equipment to a great extent is interchanged. In many of the countries the cars are equipped for both steam and electric heating; when trains include cars without electric heaters, boiler cars are added.

Other noticeable features in Europe are the lower insulation values and the lightness of the catenary contact systems. Contact wire height ranges are given in Table III.



Italian State Railways 3,000-volt d-c., high-speed passenger locomotive, group E-326

Table IV—Data for French Railways

Railway	D.C. Voltage	Electrified Mileage		No. of Elec. Locomotives	Electric Cars & Trailers
		Route	Track		
State Railway (Paris)	650	51	121	30	445
Paris-Orleans	1,500	148	615	205	240
Midi	1,500	730*	1,300*	246	45
Paris-Lyons-Medit'n	1,500	82*	194*	37	180
Total	——	1,011	2,230	518	910

* Approximate.

France

Four of the six principal railway systems in France operate electrically about 3.5 per cent of the country's total mileage (see Table IV). The 650-volt third rail Paris suburban lines of the State railway are operated using multiple unit trains with some freight and passenger traffic handled by electric locomotives. At present further extension of the electrification does not appear likely. The Paris-Orleans railway operates electrically south from Paris to Orleans (78 miles) and Vierzon (127 miles); recently a 72-mile extension from Orleans to Tours was authorized. The 1,500-volt d-c. synchronous converter and rectifier substations are supplied from the railway's hydro stations which also exchange power with commercial power systems. Motive power consists of 10 high-speed passenger and 195 medium speed freight and passenger locomotives for freight and through passenger service, and 80 multiple-unit car sets. Suburban trains consist of 1, 2, or 3 three-car 990-hp. multiple-unit sets with control equipment mounted under the car body.

The most extensive electrification is that of the Midi railway, operating in southern France along the rugged country of the Pyrenees, with three lines into Spain. An extensive network of hydro stations and high tension lines interconnected with commercial systems supply power to 1,500-volt d-c. synchronous converter and rectifier substations. Of novel interest is the use of an inclined catenary contact system. Ten high-speed vertical drive locomotives are in service for fast international trains and six locomotives were ordered recently. There are 100 smaller medium-speed passenger and 130 freight locomotives; rheostatic braking is used on all of the freight and half of the passenger locomotives, and regenerative braking on the balance. Forty-five 700-hp. multiple-unit motor cars handle local trains.

The Paris-Lyons-Mediterranean (P.L.M.) system is electrifying a section of its line in southeastern France on one of the main routes to Italy. This installation is interesting for its use of a 1,500-volt third rail, an overhead catenary line being used only at stations. Unusually powerful locomotives are used on the mountain grades.

Spain

The Spanish Northern railway has two important 1,500-volt d-c. electrifications, one in the west between Irun and Alsasua on the Paris-Madrid route and the other in the east between Barcelona and Manresa, Ripoll and Puigcerda, using multiple-unit cars and powerful passenger and freight locomotives, as well as a 3,000-volt d-c. mountain electrification on the Pajares grade in the extreme northwestern region. These lines are wide gage (66 in.). The Vascongados railway between Bilbao and San Sebastian operates an extensive meter gage system at 1,650-volts direct-current, and in western central Spain there is a meter gage 3,000-volt d-c. electrification of a road which handles principally minerals.

The electrical operation of all the trunk lines was reported by a government commission as economically justified, but because of the present financial and political conditions it will probably be some time before this extensive program, covering more than 3,500 route miles, is started.

Italy

The lack of coal resources and the abundance of water power in Italy early invited the use of electric traction. After the World War the Italian state railways, as part of their program to improve rail transportation, extended electrification to many trunk lines and adjacent branches. More than 10 per cent of the route mileage, handling about 20 per cent of the total traffic, is now electrically operated. The extent of the four electric traction systems is indicated in Table V. This diversified electric traction experience is of special interest to railway electrification engineers.

Originally adopted as the standard for the country, the three-phase 16.7-cycle 3,700-volt a-c. system in the mountainous northwestern section of the country is now one of the most extensive electrifications in the world. Traction power is purchased or generated at traction frequency and distributed by the railroad's network of low-frequency transmission lines to transformer substations. A satisfactory three-phase overhead contact system, consisting of one or two wires per phase, has been developed although it is complicated and expensive to construct and maintain. The locomotives, through refinements in design and construction, are very reliable in operation and low in maintenance costs. Two speeds, 16 and 32 miles per hr., are obtained on freight; and four speeds, 23, 32, 46, and 64 miles per hr. on passenger locomotives. The principal difficulties with this traction system are the unsatisfactory operation of collectors and contact line at high speeds and the impracticability of closely regulating the speed.

Although the three-phase low-frequency system was satisfactory for the mountain territory, its extension to central and southern Italy was not deemed desirable for it did not satisfy two requirements considered essential in selecting a system for extensive electrification:

1. For level lines a speed of 65 miles per hr. and higher should be reached easily and be capable of slight regulation.
2. To utilize to the best advantage the water power resources of the country, traction power should be of the same frequency as industrial power and where possible existing generating and transmission facilities should be used.

With these requirements in mind the three-phase 45-cycle (industrial frequency) and the 3,000-volt d-c. traction systems were selected in 1919 for trial installations. The three-phase 10-kv. 45-cycle system was installed in 1927–31 on the 107-mile line of 3.1 per cent maximum gradients crossing the Apennines between Rome and Sulmona. Three types of locomotives, also designed for operation on the low frequency system, are in service. Italian railway engineers consider this traction system superior to the low frequency system, as regards generation, transmission and conversion; however, locomotives are heavier, more complicated and expensive, and the contact system more costly to build and maintain. Despite the satisfactory operation it is doubtful if this system will be extended as it fails to meet the first of the above mentioned requirements.

The 3,000-volt d-c. system was installed initially in 1927–28 on the 63-mile line of 2.3 per cent maximum gradients between Foggia and Benevento in southern Italy. Electrical operation was recently extended 60 miles to Naples. Power for this line is purchased entirely from commercial power systems and converted in motor-generator and rectifier substations. A constant tension double contact wire catenary system is installed. For this line a freight and a high-speed passenger locomotive were developed and these two types thoroughly tested in service.

The high voltage d-c. system eventually will be used on the recently completed Naples-Rome direct line and now is being installed on the direct line under construction between Bologna and Florence. The present 82-mile line between Bologna and Florence, the central main route between northern and central Italy, has maximum gradients of 2.6 per cent with numerous tunnels and is a line difficult to operate with steam power. During 1921 to 1927 it was electrified with the three-phase 16.7-cycle system. Construction on the more direct line with lower gradients through the Apennines was started in 1920 involving the longest double-track tunnel (11.5 miles) in the world and reducing the route distance 21 miles. Completion is expected in 1934 and then the present three-phase line will be converted to the 3,000-volt d-c. system.

The extensive use of portable substations for the a-c. and d-c. systems is original and unique. For the 16.7-cycle system a 2,250-kva. three-phase transformer with oil switches is mounted on a special flat car of 100 tons total weight. A 2,000-kw. 3,000-volt rectifier unit is mounted on a partially enclosed car which weighs 82 tons complete with transformer and all switching apparatus. Two such rectifiers have been delivered for test and on new lines it is planned to use such units in place of some of the usual fixed stations.

Table V—Electrified Sections of Italian State Railways

Electrification System	Electrically Operated: First Year	No. of Locos.	Mileage: Route	Mileage: Track	Construction Mileage: Route	Construction Mileage: Track
Three-phase, 16.7 cycle, 3,700 v.	1906	731	906	1,772	59	90*
Three-phase, 45 cycle, 10 kv	1928	18	108	150		
High voltage D.C. (3,000 v.)	1927	111[a]	120	207	60	160*
Low voltage D.C. (650–800 v.)	1901	28[b]	114	220		
Total		888	1,248	2,349	119	250*

[a] Including locomotives under construction.
[b] Plus 33 motor cars.
* Approximate.

Table VI—Italian State Railway Three-Phase A-C. Locomotives

	16.7 Cycle, 3700 Volt: Freight		F & P	Passenger			45 Cycle, 10 Kv.: Frt.	Pass.
Axle classification	E	E	E	1C1	1D1	1D1	E	1D1
Group number	E550	E551	E554	E333	E431	E432	E570	E472
Year built	1909	1924	1928	1923	1924	1928	1923	1923–30
Number built	186	183	183	40	37	40	4	10
Max. speed, m.p.h.	37	37	37	62	62	64	37.5	62
Weight, tons	70	82.5	82.5	82.5	102	102	77	100
Hp.—1 hr. rating	2,200	2,680	2,570	2,680	2,680	2,760	2,270	2,660
No. of motors	2	2	2	2	2	2	2	2
No. of speeds	2	2	2	4	4	4	2	4
Method of drive	SR—SY	SR—SY	SY—SR	SY—SR	SY—SR	SY—SR	GJS—SR	GJS—SR

SY—SR Scotch yoke and side rod drive.
GJS—SR Geared jack shaft and side rod drive.

Stringing contact wire on Naples line for Italian State Railways, using 40-hp. gasoline-engine tower-car and small reel-car

Recent a-c. and d-c. locomotives have been carefully standardized. The two types of d-c. locomotives and an 80-ton type B+B branch line freight and passenger locomotive are expected to provide for all future d-c. system requirements. The same motors, contactors, resistances, compressors, gear cases, and axle bearings will be used for these three types.

The privately owned North Milan railway handles a heavy suburban traffic to the Lake District, and 75 track miles over 31 miles of route are electrically operated using the 3,000-volt d-c. system. Power is purchased and converted by rectifiers. Sixteen 720-hp. two-car multiple-unit sets and four electric locotives are in service. Since electrification, local service has been doubled and the running time reduced 35 per cent. Twin contact wires are supported by flexible strand hangers from a copper messenger.

Switzerland

Switzerland is a country of particular interest because of the early development and present intensive application of electric traction. All the through routes and most of the important local lines have been converted, leaving only secondary lines on which electrification is progressing at the rate of about 60 route miles per year.

Railway operation is beset by many difficulties; there are steep grades, many tunnels, and much single track mountain line. Coal must be imported and an assured and cheap supply is often difficult to obtain. In almost all sections of the country, however, water power is available in abundance. Electrification, therefore, has been undertaken for economic reasons, for the increased facility in handling heavy through international freight and passenger traffic, and also for national security and the further utilization of natural resources. There are two important standard gage electrified systems—the Federal railways and the Bernese Alps railway; also many electrified narrow gage adhesion and rack lines.

A special commission reported in 1914 that the electrification of certain Federal system routes was desirable economically and the single-phase 16.7-cycle 15-kv. a-c. traction system was recommended, with single-phase traction-frequency generation and transmission by railway owned generating stations and high voltage transmission lines. Plans were being made for the conversion of the St. Gothard line when the World War intervened. In 1923, because of the unemployment situation and coal difficulties, an accelerated program was adopted with approximately a 20 per cent subvention by the government, and phenomenal progress was made during the five years following.

Table VII—Italian State Railway D-C. Locomotives

	3000 Volt		650 V.
	F & P	Pass.	F & P
Axle classification	B + B + B	2C2	1 C1
Group number	E 626	E326	E321
Year built	1925–31	1931	1923
Number built	91	12	17
Max. speed, m.p.h.	56	87	62
Weight, tons	98	119	75
Hp.—1 hr. rating	2,400	2,400	1,840
No. of motors	6	6	2
No. of speeds	9	9	
Method of drive	Flexible Gear	Flexible Gear	SY–SR

(SY–SR) Scotch yoke and side rod drive.

Midi railroad type B_o-B_o, 1,400-hp. 86-ton 1,500-volt d-c. electric freight locomotive. Similar locomotives with different gear ratio are used for much of the passenger service

Table VIII—Swiss Federal Railway Electric Locomotives

Single phase 16.7-Cycle, 15-Kv. Contact Line

	F & P	Pass.	Pass.	Pass.	P & F	P & F	Freight
Axle classification	2D1	2C1	2C1	1C1	1B + 1B1	1B + B1	1C + C1
Ry. designation	Ae 4/7	Ae 3/6 I	Ae 3/6 II	Ae 3/5	Be 4/7 I	Be 4/6 I	Ce 6/8 I
Year built	1926–31	1928	1922–26	1921–25	1921	1919–23	1920–22
Number built	125*	114	60	26	6	40	33
Max. speed, m.p.h.	62	56	56	56	47	47	40
Weight, tons	130	105	109	90	122	121	141
Hp —1 hr. rating	2,800	2,100	2,000	1,800	2,400	2,040	2,240
Trac. ef.—1 hr. lbs.	25,800	19,400	18,300	17,000	24,350	23,400	36,800
Number of motors	3	3	2	3	4	4	4
Drive	Geared	Geared	GJS–SR	Geared	Geared	GJS—SR	GJS—SR

* Including 33 locomotives under construction.

GJS—SR Geared jackshaft and side rod drive.

Catenary line and structures on Swiss Federal Railways, showing bracket pull-off pole, 16-kv. insulation and wire screen highway protection

Electric locomotive design has been standardized so that interchangeable equipment is furnished by the three large electrical manufacturers, with another firm making all of the mechanical parts. In recent years the individual axle drive has been preferred for high speed passenger service, 60 per cent of all the locomotives being of this type; the side rod drive is used mainly for the slower services. One-man locomotives are used extensively in freight and local passenger services by the use of the "dead-man" controller. Two new locomotives of about 7,200 hp. recently were completed. All transformer tap changing is done on the high voltage side to avoid handling the large secondary currents with contactors. As on some other locomotives, regeneration is provided only to the extent of the locomotive weight and is intended for use to increase the safe speed when operating light down mountain grades.

The other major electrified system comprises 164 route miles operated by the Bernese Alps railway, which is owned by the Canton of Bern. This line was the first to use the present Swiss standard traction system, installing it for trial in 1910.

Austria

Electric traction was installed on the mountain lines of western Austria for reasons similar to those of Switzerland and to compete with paralleling international routes being electrified in other countries with a reduction in running time which would divert traffic from the Austrian lines. The same traction system (single-phase 16.7-cycle 15-kv.) as used in neighboring Germany and Switzerland was adopted, and, as in these countries, most of the power is generated and transmitted in traction form by railway-owned hydroelectric plants and transmission lines. The locomotives are side rod drive with jackshaft and individual axle drive with geared horizontal and bevel-geared vertical motors. Because of the financial conditions and the present low price of coal the further electrification of some 500 route miles has been postponed.

Germany

The extensive use of electric traction in Germany began after the World War. There are four important and several smaller electrified sections of the German State railways located in widely scattered parts of the country. Three of these districts, the Bavarian, Silesian and the Central, use the single-phase 16.7-cycle, 15-kv. a-c. system adopted as the standard for trunk lines, and the Berlin district an 800-volt d-c. third-rail system for a rapid-transit suburban service. Single-phase, 15-cycle, 15-kv. power is used on a 30-route-mile electrification at Basle and 25-cycle, 6-kv. power on the 23-mile Hamburg installation.

In the Bavarian district through freight and passenger trains and heavy suburban traffic from Munich are handled electrically over a total of about 1,000 track miles on 434 miles of route, which gradually is being extended. Most of the power is purchased, using special traction-system generators and transmission lines. A total of 190 passenger, freight, and switching locomotives and 37 motor-car sets are assigned to this section. Most of the freight and some of the passenger locomotives are the side rod drive type with geared jackshaft; high-speed passenger locomotives are type 2D1 or 1D1 individual axle drive. Multiple-unit car trains consist of one or two units, each consisting of a two-motored 750-hp. steel car and three trailers. Both the air-cooled transformer and the oil circuit breaker are in a special compartment. The locomotives and motor cars have "dead-man" control for one-man operation.

The mountain road electrification between Breslau

New St. Gothard line 7,200-hp.-$1B_o1\ B_o1 + 1B_o1B_o1$ locomotive for Swiss Federal Railways, prior to installing electrical equipment

and Gorlitz in the Silesian district includes about 217 route miles and 507 track miles. Power is generated by the railway at traction frequency, utilizing a very low grade of coal. The Central district (Leipzig-Halle-Magdeburg) has a heavy traffic which is handled at high speeds over fairly level country, using locomotives and motor cars on about 118 electrified route miles and 409 track miles. Power is generated in traction form, using a peat that cannot be burned in locomotive boilers.

The Berlin suburban lines were electrified in 1924 to furnish a rapid transit service on 145 miles of route (365 miles of track) using multiple-unit car equipment. Purchased power is converted by synchronous converters and rectifiers; the rectifier installation is the largest in the world for a single system. Contrary to common practise the anode and rectifier tank are at ground potential and the third rail is negative.

A meter gage, 12-mile 1,650-volt, d-c. railway, the Zugspitze, was recently completed to the highest mountain peak in Germany, using an adhesion, rack and aerial line. Glass-tube rectifiers convert three-phase 50-cycle power for traction purposes.

German locomotive design and construction also are standardized. Air blast transformers are used and now the electrical manufacturers are perfecting an air blast circuit breaker so that no oil will be required on the locomotive or motor car.

Sweden

Sweden is rich in water power resources, but entirely lacking in coal deposits, hence careful consideration has been given to the advantages of electric traction. The State railway system, operating most of the trunk lines and about 40 per cent of the total mileage, now has more than 14 per cent of the route mileage and 25 per cent of the traffic electrically operated. A very extensive program of electrification extension is under way and scheduled for completion in 1934.

One of the first electric installations (1912–1922) is the Northern Ore line. This 287-mile line, which goes 170 miles north of the Arctic Circle and is therefore the most northerly electrified railroad in the world, handles heavy ore traffic from the iron mines at Gellivare and Kiruna east to Lulea on the Gulf of Bothnia and west to Narvik in Norway on the Atlantic Ocean. The 15-cycle 15-kv. single-phase a-c. traction system, with high voltage single-phase transmission to track-side substations from a central mixed-frequency hydroelectric plant, was adopted.

Four-car multiple unit suburban train at Munich. There is one motor car with three trailers

After the war electrical operation was considered for the Stockholm to Gothenburg trunk line and the government again studied the matter of a traction system, concluding that the single-phase 16.7-cycle, 16-kv. a-c. system would be satisfactory. Careful study of the location of a negative return wire on the catenary structure and the use of booster transformers for minimum communication circuit interference satisfied the government communications board, which cabled their circuits or removed them from the railroad right-of-way. Traction power was obtained from the existing commercial power stations and transmission networks by installing frequency-converter substations about 58 miles apart without paralleling traction-frequency feeder or transmission lines.

A geared jackshaft side rod drive type 1C1 locomotive, identical for both freight and passenger services except in gear ratio, was adopted as standard. These locomotives handle a 550-ton passenger train or 990-ton freight train over the profile of 1 per cent maximum gradients. Sweden is now the only important country that has not at least partially adopted the individual axle drive, and is the only country extensively using a wooden locomotive cab.

In 1931 electrification of the 392-mile trunk line south from Stockholm to the ferry terminals at Malmo and Tralleborg, and three branches totaling 177 miles which connect this line with the Gothenburg electrification, was authorized at an estimated gross cost of about $17,000,000. Complete electrical operation is to be started in 1934. Com-

mercial power will be purchased from existing power systems without the construction of additional high tension lines, and six motor-generator frequency-converter substations having an average spacing of 70 miles will supply power to the contact line. As the branch lines do not require additional substations there is an average of 90 route miles per substation. Seventy-five standard freight and passenger locomotives, 21 switching and 8 battery-trolley locomotives have been ordered and are now under construction for this electrification.

A comparison of estimated operating costs shows a very favorable annual saving above all fixed charges with electric operation. The eventual electrification of about 600 route miles of other trunk lines is contemplated, which will then complete the electrification of the government system's main routes.

At Sundsvall a privately owned railway is completing a 12-mile electrification using the 1,500-volt d-c. system and 8 motor-car and trailer sets. Many of the smaller privately owned short railways throughout the country have adopted with great success diesel-electric cars on branch lines of light traffic.

Denmark

The Danish state railways have under consideration the electrification of the heavier traffic suburban lines in the vicinity of Copenhagen, to increase the capacity of the present congested trackage through that city, and to effect economies in operation. Electrical operation of about 23 miles of route using multiple-unit equipment is contemplated, and a d-c. overhead contact system at 1,500 or 3,000 volts was studied.

Gasoline-engine passenger cars, some direct drive and others electric drive, and diesel-electric locomotives are used extensively on branch lines and on the main routes. Two type 2D2 900-hp. diesel-electric locomotives were recently delivered to the railway; these locomotives are designed to handle a 275-ton train at 46 miles per hr. and have an operating range of 370 miles, thereby enabling the longest round trip to be made without refueling.

The Netherlands

Approximately three-quarters of the country's railway mileage is operated by the Netherlands railway, which has about 7 per cent of its route now under electrical operation for passenger service, using multiple-unit cars. In May 1931, the lines from Amsterdam to Uitgeest and Alkmaar, and Velsen to Uitgeest were converted to electrical operation, in addition to the Amsterdam-The Hague-Rotterdam line and branches which have been electrically operated since 1927. Purchased power is used entirely, and converted to 1,500-volts direct current by automatic rectifier substations which are supervisory controlled from adjacent interlocking towers. The one motor-generator substation is manually operated. On the earlier installation multi-unit substations were spaced 6.9 to 10.2 miles apart with intermediate sectionalizing tie stations. The recent installation consists of single-unit substations spaced about 4 miles apart. The contact system is of the twin contact wire type, and is unique for the suspension of both contact wires from the same hanger.

Rolling stock of the most modern type is used, and eight different 760-hp. motor or trailer cars of various passenger classes are combined as desired to make up trains of from 2 to 10 cars. The latest motor cars have roller-axle and motor armature bearings. As the railway faces severe competition from motor buses, other heavy traffic passenger lines, as from Amsterdam to Utrecht, probably will be electrified. The

(Above) New Swedish type U_b switching locomotive equipped with four control positions in a high center cab

(Right) Unique type of motor-generator freight locomotive constructed in 1930 for Austrian State Railways. It operates on a single-phase $16^2/_3$-cycle 15-kv. contact line and is equipped for full train weight regeneration

electrical operation of freight and through international passenger trains is not planned at present.

GREAT BRITAIN

The three outstanding recent electric traction developments are:

1. The Ministry of Transport report on main line railway electrification (1931) commonly referred to as the "Weir Report."

2. Extension of the Southern Railway's third-rail electrification to Brighton on the Channel coast.

3. Inauguration of electric service between Manchester and Altrincham using 1,500-volt d-c. multiple-unit equipment.

With the exception of the Newport-Shildon 1,500-volt d-c. line all of the electrification is suburban and much of the mileage is in the London district; other installations are located at Manchester, Liverpool, Lancaster, Newcastle-on-Tyne, and Newport. During the past decade, with the formation of the national grid system for electric power transmission and distribution, the government has viewed with increasing interest the possibility of using electric traction on the railroads and various committees have reported on this subject. The Pringle (1927) report definitely recommended the use of direct-current, either 750-volt third-rail or 1,500-volt overhead, with the possibility of considering 3,000 volts for special conditions. The Weir report (March 1931) recommended that if the railroads are to be electrified practically all of the lines must be converted to avoid the uneconomical conditions incidental to dual steam and electric operation. This stupendous project, covering almost 20,000 route miles, would be spread over a period of 20 years, the total gross expenditure being estimated at $1,964,000,000.

The Southern Railway's London suburban electrification, the largest of its kind in the world, has 300 route and 800 track miles electrically operated. With the completion of the Brighton electrification at the end of 1932 the electric system will include 965 track miles on 350 miles of route; this is about 18 per cent of the company's mileage. The 650-volt d-c. third-rail distribution system is supplied by 52 synchronous converter substations converting from 25 cycles. Eighteen supervisory-controlled single-unit rectifier substations are to supply power for the Brighton extension from the 50-cycle national grid sytem. Multiple-unit equipment is used entirely, in trains of from 2 to 9 cars. The standard motor unit consists of two 550-hp. motor cars and an intermediate trailer; a few two-car motor units were purchased recently. Two-car trailer units are used between motor units. All control apparatus including resistance grids is placed in a compartment of the motor car. There are a total of 1,948 cars of which 832 are motorized; most of these have been converted from former steam equipment.

The Manchester, South Junction, and Altrincham railway is the first electrification to follow the 1927 committee's recommendation of 1,500-volt direct current. Electric service with multiple-unit equipment was inaugurated in May 1931. The line is 8.7 miles long (28 track miles) and was electrified to meet bus competition more effectively. Purchased power is converted by synchronous converters and a rectifier. The catenary contact system consists of a copper messenger, stranded auxiliary, and a 318,000 cir. mil contact wire, totaling 1,000,000 cir. mils in conductivity. Three-car units consisting of a motor car, trailer, and control trailer are used; trains may be made up of 1, 2, or 3 such units. Motor cars, weighing 63 tons, have four 330-hp. motors and a maximum safe speed of 70 miles per hr.; trailer cars weigh 35 tons.

European railways are apparently well satisfied that the operating economies, increased speed, cleanliness, increased track capacity, and use of natural resources such as water power or low grades of coal, are advantages that justify further extension of railway electrification even during a severe economic crisis. The execution of such projects during times of depression has been of material assistance in alleviating unemployment in several of the countries. Perhaps America could profitably follow such an example.

Impulse Testing of Large Transformers

Impulse voltage tests provide valuable information concerning a transformer's ability to withstand high voltage surges in service. By making such tests with the transformers excited, power current will flow into any faults which occur, thus providing unmistakable evidence regarding the nature and location of such faults.

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PRESENT standard dielectric tests at low frequency no longer are considered to give a satisfactory measure of the real strength of transformer insulation. This fact was emphasized during the recent A.I.E.E. winter convention, at which the question of impulse testing of large power transformers received considerable attention. In general, engineers who discussed the question at that time agree that impulse tests would afford valuable information concerning the ability of transformers to withstand surges encountered in service, and that steps should be taken to establish a standard test pro-

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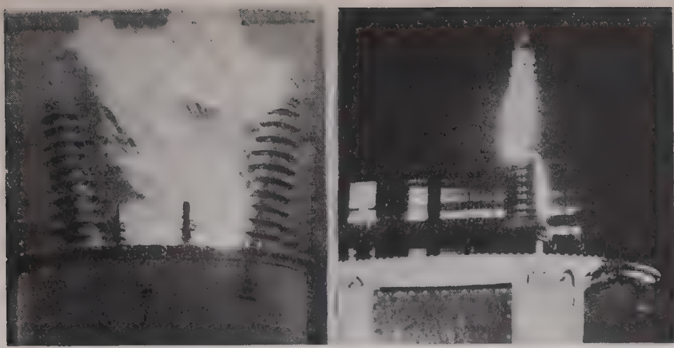


Fig. 1. Transformer bushing flashovers (left) with superposed surge and normal-frequency voltages; (right) with surge voltage only applied

cedure for impulse testing. It was suggested further that the A.I.E.E. electrical machinery committee might undertake this task.

Development of a suitable method of impulse testing for transformers involves several problems if such methods can be considered safe and reliable measures of insulation strength. One of the principal difficulties encountered is the detection of insulation failures when they occur, and some question exists as to whether a method less thorough than complete disassembly of the transformer insulation is adequate for this purpose. The problem of detecting insulation failure is solved, however, by the simultaneous application of surge voltage and normal frequency exciting voltage, so that failure is accompanied by the flow of power current.

When an insulation failure occurs during a normal-frequency dielectric test, the fact that failure has occurred is demonstrated by the obvious effects of the power current that flows into the fault. In the surge test as ordinarily made, the energy discharged by the surge generator may be insufficient to produce unquestionable physical effects, if the failure occurs within the transformer winding. If on the other hand the surge be applied with the transformer excited, as in normal service, an insulation failure caused by the surge voltage would be followed by power current; the fact of such failure would be as patent and as unmistakable as in the case of a failure in service, or of a failure during a normal-frequency dielectric test. (See Fig. 1.)

Simultaneous application of surge and power voltages has been recognized generally as the satisfactory solution of this problem, and this combination test was carried out successfully on distribution transformers two years ago. In applying the method to high voltage transformers, however, additional difficulties are encountered in obtaining a simple and practical method of preventing the transformer voltage from injuring the surge testing equipment. This latter problem has been solved by F. J. Vogel of the Westinghouse company by an ingenious application of the Torok tube, an arc rupturing device operating on the deion principle.

In Fig. 2 is shown a circuit developed for testing high voltage transformers by the method just outlined and employing a deion gap as mentioned. In this diagram, the surge generator is tripped by gaps *3* and *4*, and these in turn by the voltage from the condenser C_t. If a positive surge is required from the generator, a negative voltage is required from C_t. Gap *3* is set so that the voltage of C_1 is not quite sufficient to cause breakdown; gap *4* is set at a lower voltage than gap *3*. A small negative voltage from the tripping condenser trips gaps *3* and *4* in succession, gaps *1* and *2* insuring the synchronizing of the surge with the 60-cycle voltage. Voltage at gap *1* is a maximum when voltage from the tripping transformer is at maximum positive polarity at the crest of the wave. Gap *2* is set high enough only to with-

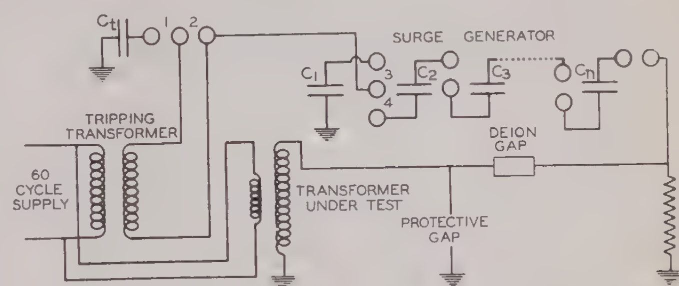
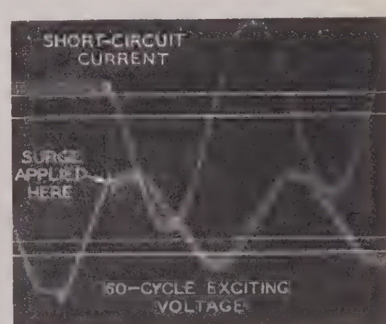


Fig. 2. Equipment for testing transformers with surges applied at crest of exciting voltage wave

Application of this method to high voltage transformers was made possible by use of the deion gap to protect the surge generator from the transformer voltage

Fig. 3. Oscillogram of transformer bushing flashover showing application of surge and beginning of short-circuit current at crest of exciting voltage wave



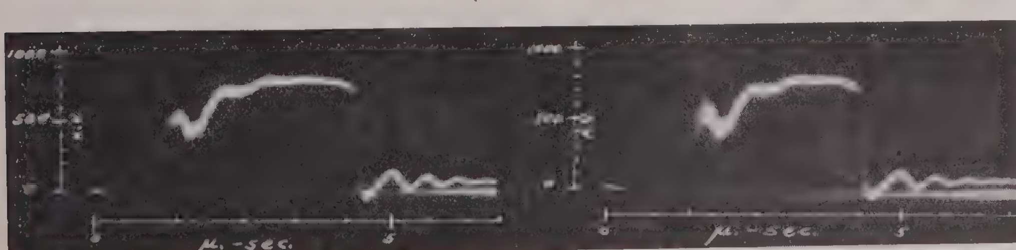


Fig. 4. Addition of deion gap to circuit does not affect surge voltage; (left) surge voltage wave with gap; (right) without gap.
For this test, oscillograph was connected between surge generator and deion gap

stand the 60-cycle voltage. If gap *1* is set so that it will just break down when the 60-cycle voltage is applied, the crest of the wave will be picked off automatically.

Operation of the circuit described is illustrated by Fig. 3, which shows an oscillogram taken during a bushing flashover on a 138-kv. transformer. Application of the surge and the start of the short circuit are indicated clearly. Timing of the surge is arranged so that it is imposed at the crest of the 60-cycle voltage wave. Experience has shown that with the surge and power voltages synchronized in this manner, power current will follow in every case in which the transformer insulation fails to withstand the surge voltage. It should be noted further that the use of the deion gap as shown in Fig. 2 does not affect the surge voltage. This is demonstrated by Fig. 4, which shows oscillograms of surge voltage during bushing flashovers with and without such a gap in the circuit. It may be noted that the voltage and time-lag of the flashovers are practically the same in both cases.

This development is particularly timely considering the discussion on the subject at the recent A.I.E.E. winter convention mentioned in the beginning of this article. Availability of this test procedure opens up the possibility of an entirely new basis for establishing the sufficiency of transformer insulation. Furthermore, it brings within the range of practical discussion the project of standardizing the test procedure, test wave, and voltage values for surge testing.

Design Features of Potentiometers

Fully nine-tenths of all potentiometers now being built are said to find their way into industrial plants. Low-resistance instruments are shown to possess many advantages over those with high resistance.

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POGGENDORF'S "compensation" circuit, from which all potentiometer circuits have been developed, was brought out about the middle of the nineteenth century. This original circuit was devised for measuring the open circuit e.m.f. of primary cells; in all precise potentiometers of today, the open circuit voltage of a primary cell is used for standardizing the potentiometer current. As practically all of the primary cells used with potentiometers develop an open circuit e.m.f. a little in excess of 1 volt, most potentiometers have been designed to have ranges of approximately 1.5 or 2.0 volts. An important exception arises in the case of potentiometers designed for precise measurements of temperature with thermocouples. Such instruments usually are designed to have a range of approximately 0.1 or 0.01 volt.

Based upon "Design of Potentiometers" (No. 31-118) presented at the A.I.E.E. summer convention, Asheville, N. C., June 22-26, 1931.

Potentiometers have been designed with a range as high as 15 or 16 volts, but usually such a high range is not required. It is preferable not to connect high voltage directly to the potentiometer, but to extend the range of a 1.5- or 2-volt potentiometer to any desired value by means of a voltage divider, commonly known as a "volt-box." It is usual practise to equip potentiometers with range-changing devices, so that two or three ranges are available in one instrument.

Potentiometer Resistance

No direct relationship exists between the potentiometer range and its resistance. It is true that all low range potentiometers for use with thermocouples are designed to have low resistance, as a high resistance in the potentiometer circuit would interfere with obtaining the desired sensitivity; but it does not follow that a high range instrument should have a high resistance. While a high resistance may be used in a high range potentiometer, a low-resistance potentiometer is preferable for the following reasons:

1. Inherently, a low-resistance potentiometer makes possible a higher sensitivity than can be obtained with a high-resistance instrument.
2. Errors due to current leakage between the potentiometer parts are much smaller in a low-resistance instrument.
3. Low-resistance coils are more stable than high-resistance coils.
4. Proper galvanometer damping is easy to obtain with a low-resistance potentiometer and difficult to obtain with a high-resistance instrument.
5. In a low-resistance potentiometer at least one-tenth of the range may be covered with a slide wire; this results in a simple and inexpensive construction.
6. For the same sensitivity, a low-resistance potentiometer permits using a higher resistance in the volt-box.

Distinct advantages result from the use of low resistance even in a high range potentiometer where the high-resistance instrument is not barred out definitely because of lack of sensitivity. For in-

stance in measuring current by measuring the potential drop across a current shunt, if shunts of equal energy dissipating capacity are used, the low-resistance potentiometer permits the use of a more simple and rugged form of galvanometer; if galvanometers of the same sensitivity are used, then the energy dissipating capacity, and consequently the size and cost of the current shunt, may be reduced when working with the low-resistance potentiometer.

Lower operating current represents the only advantage which may be claimed for the high-resistance potentiometer; this advantage, however, can be shown to be more apparent than real. In the days when a 50- or 60- ampere-hour storage cell was a fairly expensive item and when it was necessary to reset all of the potentiometer dials in order to check the potentiometer current against the standard cell, a potentiometer requiring much less current than 0.01 or 0.02 ampere probably had a real advantage. Now that fairly large storage cells are available at small cost and potentiometers are designed so that the current may be checked instantly without resetting the dials, an instrument requiring as much as 0.01 or 0.02 ampere is at no disadvantage, but on the contrary is at an advantage because with the higher current any small leakage currents produce much smaller errors. In Fig. 1 is shown the extremely small drift in current for a typical potentiometer requiring 0.02 ampere supplied from a storage cell of 60-ampere-hour capacity.

Reference already has been made to the possibility of using a slide wire for the lower part of the range of a low-resistance potentiometer. As a matter of fact, however, it is not at all essential and almost all of the low-resistance potentiometers designed for making precise temperature measurements with thermocouples are equipped with dial switches throughout.

A low-range, low-resistance, dial-type potentiometer recently proposed is shown schematically in Fig. 2. This instrument has a low total resistance (less than 15 ohms and substantially constant) and the circuit arrangement is such that errors due to resistance variation and parasitic e.m.f.'s at the switch contacts are reduced to less than one step on the fifth dial.

While the instrument shown in Fig. 2 has six dials, not more than five are intended to be used at one time, as the use of all six would assume a higher accuracy in the standard cell and in the resistance adjustments than is obtainable in ordinary practise. The sixth dial is included as the equivalent of a range-changing device, that is, when using dials I to V inclusive, the range is approximately 0.1 volt; when using dials II to VI inclusive, it is about 0.01 volt.

Deflection Potentiometers

In the deflection potentiometer, the principal part of the potential being measured is balanced against a known potential just as is done in an ordinary null potentiometer; the remaining small portion of the unknown potential is read from the deflection of a calibrated galvanometer. The fundamental requirement in the design of a deflection potentiometer is that, for all connections and adjustments of the instrument, there must be no appreciable change in the galvanometer circuit resistance.

Aside from its use in photometric measurements, the most important application of the deflection potentiometer is in checking large numbers of portable indicating instruments. In discussing this latter problem, Dr. H. B. Brooks, of the United States Bureau of Standards, points out that null potentiometers are the most accurate for the purpose, but require too much time to use. Doctor Brooks further shows that long scale laboratory standard deflecting instruments, while faster in operation, are not sufficiently accurate for the purpose. He concludes that "the need unquestionably exists for a type of instrument for current and voltage measurements which will have properties intermediate between those of the ordinary deflection instrument and the elaborate potentiometer."

It is interesting to note that although the deflection potentiometer does provide an instrument intermediate in accuracy between the null potentiometer and the laboratory standard deflection instruments, it is not intermediate in speed of operation. It is faster than either of the other two. In the deflection potentiometer, the galvanometer pointer is short and light and this results in a short period. Furthermore, it is unnecessary to take the time to estimate tenths of a division. Because the position of the pointer does not change very much and need not be observed more closely than to one

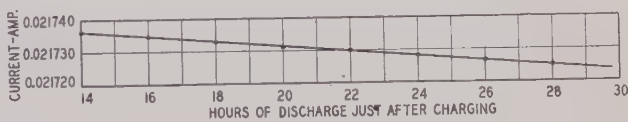

Fig. 1. Current drift for a typical 100-ohm potentiometer supplied from a lead storage cell

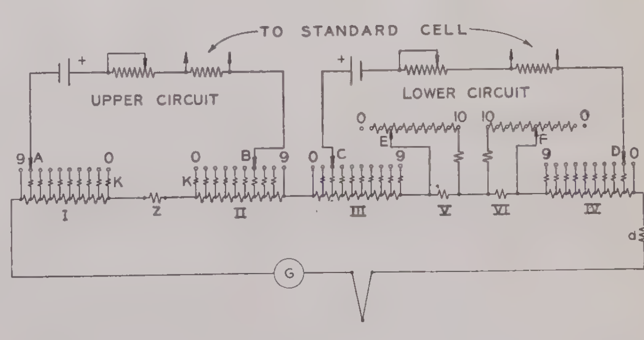

Fig. 2. Schematic diagram of a recently proposed low-resistance potentiometer with two ranges (0.1 and 0.01 volt, respectively) and five dials

This instrument is especially adapted for thermocouple measurements. Upper and lower circuits are connected so as to utilize the difference of the two potentials, thus avoiding the necessity of reducing both potentials to zero to obtain a zero reading on the potentiometer

division, it is unnecessary for the operator to change his position frequently in order to remain in line with the pointer. This latter precaution is essential in reading laboratory standard deflection instruments to avoid parallax errors.

In conclusion it may be of interest to point out that the use of potentiometers in industrial plants has increased remarkably in recent years. A fair estimate indicates that nine-tenths of the potentiometers put into use each year go into industrial plant applications and only one-tenth into laboratory service. This is not due to any falling off in the laboratory uses of potentiometers, but rather to the rapid increase in industrial plant uses of the instrument, in the form of portable indicating potentiometers and automatic recorders and controllers.

Tie Line Load Control

Regulation of tie lines interconnecting two electric power systems is a problem of load control rather than one involving principally system frequency; for best results, the control equipment must be automatic. Apparatus developed to meet this need is described in this article, and the results from two years' operating experience are outlined.

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PARALLEL or interconnected operation of several power systems has brought to the fore a new and most important problem; namely, that of controlling the interchange of power between the several systems. This problem first came into prominence under the name of frequency control and many engineers attacked it from that point of view. As a matter of fact the problem is one of load control instead, and as yet little has been done toward its solution. The division of power in a loop under the control of phase shifting equipment is a related problem, but should not be confused with the control of total interchange by the prime mover governors. Attempts to regulate two or more interconnected systems with an automatic frequency regulator on each system promptly will develop the fact that the load variations on the systems will be so dissimilar that power flow over the tie lines cannot be regulated in this manner. In fact it has been observed in some cases that when the bulk of the load change falls upon one system, the power flow over the tie line exceeds the load change by the amount required to accelerate or retard the systems.

Recognizing the problem as one of load rather than frequency control, the Duquesne Light Company several years ago enlisted the cooperation of several equipment manufacturers in a series of load control experiments. The tests were made on the 36,000-kva. 132-kv. tie between the Colfax station of the Duquesne Company, and the Springdale station of the West Penn Power Company. As a result of this and continued investigation, automatic load control

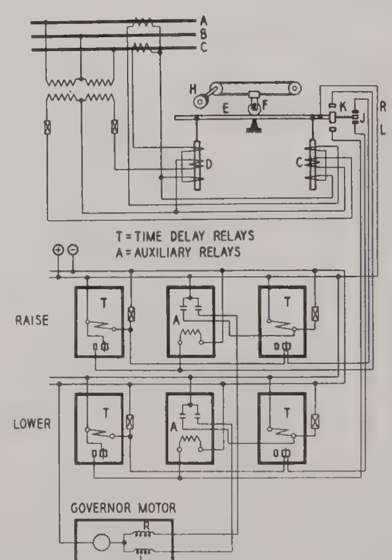

Fig. 1. Westinghouse solenoidtypeautomatic load regulator for interconnecting tie lines

With weight F immediately above the fulcrum, arm E is balanced and requires zero watts in coils C and D to maintain balance. Any power flow through the coils will cause the arm to raise or lower depending upon the direction of flow. For small changes in load contact J engages either the "raise" or "lower" stationary contacts R or L. These contacts send an impulse to the governor motor through time delay relays approximately $2^1/_2$ sec. after the contacts have closed. If the period of contact engagement is less than $2^1/_2$ sec. no correction results. A second set of time delay relays is provided to limit the length of impulse delivered to the governors to a predetermined value. To take care of large load changes, a second set of contacts K is provided to operate the speed changer motor directly through auxiliary relays without time delay. Contacts K are set to close for approximately 10,000 kw. change in load, but hunting of the regulator in this zone is prevented by the opening of these contacts at 5,000 kw. Below this value the auxiliary contacts J to return the line load gradually to normal.

Based upon "Tie-Line Control of Interconnected Networks" (**No. 31-127**) presented at the A.I.E.E. Pacific Coast convention, Lake Tahoe, Calif., August 25-28, 1931.

over the tie line and automatic control of the generator output in accordance with a predetermined program, both being supervised by or subservient to automatic frequency control, have been in successful operation at the Colfax station for some time. While many improvements no doubt are yet to be made, operation of existing equipment exceeds expectations extant at the time the investigational work was started some two years ago.

The maximum economy possible as a result of interconnection will not be obtained unless the most efficient loadings of the several generating units on the interconnected system are adhered to closely. This loading must be anticipated and must take account not only of the inherent efficiency of the generating station and units, but numerous other factors. Since maximum economy cannot be obtained with manual control, for the most advantageous operation the control must be automatic.

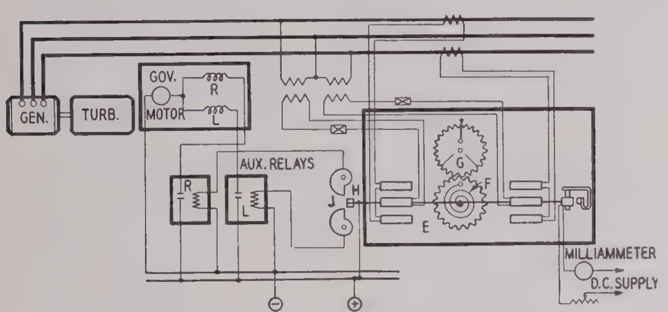

Fig. 2. Westinghouse Kelvin-balance type automatic tie-line load regulator

A calibrated spring F attached to a geared disk allows the torque due to the power in the Kelvin balance to be neutralized by rotating the disk G to the right or left; a balance thus can be made at any load within the limits of the spring F. Variations in load cause the balance to deflect contact H which in turn makes contact with the motor-driven rotating cams J thereby routing "raise" and "lower" impulses to the governor motor. As the unbalance decreases the period of contact engagement with the cams decreases and the duration of impulses to the governor motor also decreases thus providing an anti-hunting feature. Disk G can be rotated by a position transmitter, or a D'Arsonval element may be attached to the lever E to counteract the torque in the balance, making the device readily adapted to remote control

Such control must be simple, reliable, accurate, and easy to set for any desired division of load between generating units.

Performance of a tie line connecting two large power systems involves the rate of load change, and the inertia and sensitivity of the prime mover governors, as well as the electrical characteristics of the line. A load change on one system causes a redistribution of the load between the various prime movers, and also a transient distribution which occurs during the period of adjustment to the new load. This transient condition is not noticeable in a closely tied system such as the average metropolitan utility. However, if there is only one tie line connecting two systems, these load transients are concentrated and assume considerable importance. The chief requirements of a successful tie-line load regulator therefore are that it must not respond to these small *transient* load changes, but it must respond to

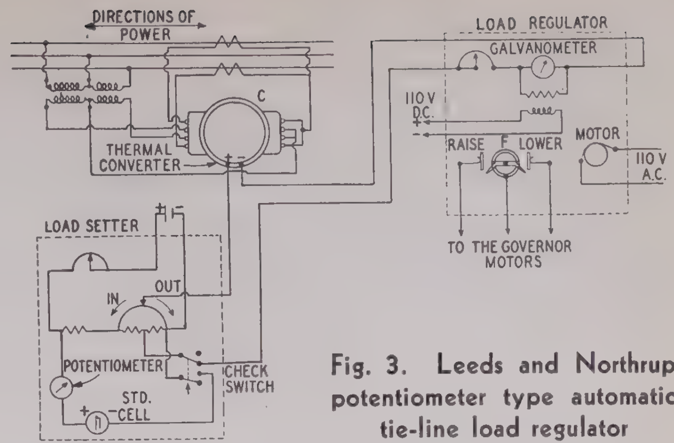

Fig. 3. Leeds and Northrup potentiometer type automatic tie-line load regulator

The load setter is a potentiometer with a calibrated dial, and is adjusted to give a potential equal to the thermocouple potential of the thermal converter for a given tie-line load. These two potentials are connected in opposition through a sensitive galvanometer. This galvanometer deflects in proportion to the difference in potential between the load setter and the thermocouples of the thermal converter. Any unbalance indicated by the galvanometer is checked by the rotating cam mechanism F, which delivers corrective impulses to the turbine governor in proportion to the load errors.

small *sustained* changes. However, when large load changes occur the regulator must respond whether such fluctuations are temporary or sustained.

Tie-Line Load Regulators

Three types of tie-line load regulators are shown in Figs. 1 to 3. The first type (Fig. 1) was devised primarily to eliminate corrective action due to transient changes, but to respond rapidly to load changes of reasonable magnitude. It consists essentially of two solenoids connected to two phases of the tie line, and arranged to assist each other in balancing an arm which carries two sets of control contacts on its outer end. Time delay relays prevent the regulator from responding to small transient changes. This device has shown considerable promise, in that it does not cause corrections to be made which must be counteracted immediately by those of a reverse order.

A large change of turbine loading to counteract load in a tie line results in considerable energy being supplied to the system to accelerate it while changing the phase angle relation across the tie line. It can be seen that after the phase angle is changed this energy still is available to supply load, which results in an overshooting of the proper value. It is essential that any regulator responding at a rapid rate must have a wide zone about the final position in which the load corrections are made in small increments.

This first regulator is not well adapted to remote control, and for applications involving this feature, another design utilizing the Kelvin balance (Fig. 2) has been developed. No time delay relays are used with this device; it will cause more corrective impulses to be delivered to the governor motors than the device first described, although it is somewhat slower in correcting large errors due to rapid changes of load. Under average conditions, however, it will maintain a closer integrated load.

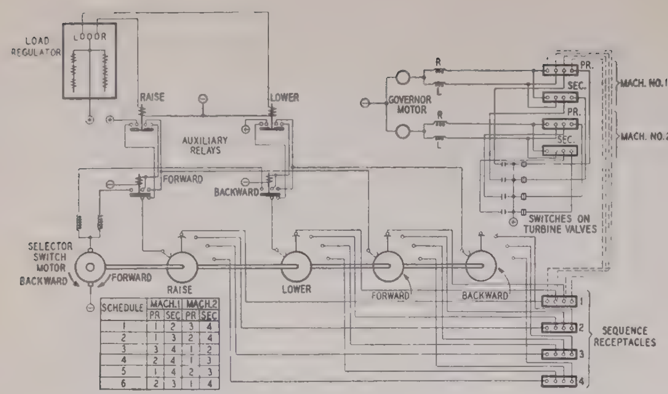

Fig. 4. Automatic program load controller for use with tie-line load regulators

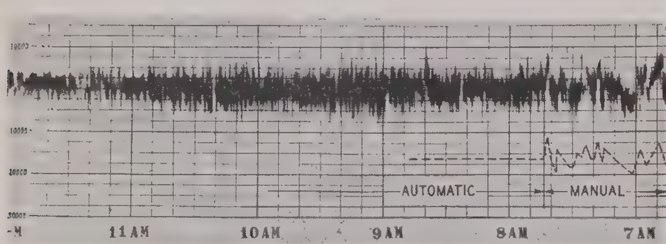

Fig. 5. Comparison between manual and automatic control. Broken line shows average of load swings

The solution of the problem of tie-line control offered by the Leeds and Northrup Company consists essentially of a master element comprising a thermal converter and a load setter as shown in Fig. 3. The thermal converter is similar to the Lincoln thermal demand meter except that instead of using a bi-metal strip to indicate the kilowatt load, thermocouples are inserted which produce a potential for transmission to suitable receiving apparatus. This device tends to change the turbine loads until the tie-line load flowing through the thermal converter sets up a potential equal to that of the load setter. This control gives very satisfactory operation.

Program Load Control

In the past where frequency control has been adopted, common practise has been to confine the regulating to one station and usually to one generating unit. When the regulating device controlled more than one unit, the division of load between units sometimes was found to be erratic; therefore load balancing schemes were devised to enable the various units to carry their proper share of load increments.

These devices are relatively simple and perform satisfactorily, but the principle of dividing all load increments proportionately between units in a steam station does not necessarily make for maximum efficiency. Most operators have considered the output of the machine and have not taken into account the inefficiency due to operating with steam control valves in a throttling position. In the equipment developed to meet the requirements established by the Duquesne company operators, load scheduling is based upon turbine valve positions rather than upon generator output. Thus each turbine is maintained at its most efficient valve opening regardless of the effect of the many variables entering into the position of the valve with reference to the load.

In Fig. 4 may be seen a schematic diagram of equipment used to obtain automatic division of load in accordance with the predetermined program loading at the Colfax station. Six generating units are installed in this station, two of them of 60,000-kw. capacity each; two of 41,250 kw. each; and two of 30,000 kw. each. On the larger steam turbines the nozzles are arranged usually in three groups, each fed from the primary, secondary, and tertiary valves, respectively. These valves are equipped with auxiliary switches to establish the proper sequence of loading. Referring to Fig. 4, the motor-operated selector switch routes the "raise" or "lower" impulses from the tie-line load regulator through the load scheduling device to the turbine governors. In order to simplify the description and diagram as much as possible only two machines have been shown, each with one primary and one secondary valve.

Six loading schedules are shown in the table (Fig. 4); to set up any one of these schedules, a system of receptacles and plugs is used, four machine receptacles and four sequence receptacles being required for the case illustrated. The selector switch has four independent contact arms, two of which are used for routing the "raise" or "lower" impulses and two for controlling the selector switch driving motor. The position of the selector switch is determined by the position of the valve auxiliary switches and also by the way in which the machine and sequence receptacles are connected by jumpers. For example consider that machine No. 1 primary receptacle is connected to sequence receptacle No. 1, No. 1 secondary to sequence 2, No. 2 primary to sequence 3, and No. 2 secondary to sequence 4 receptacles. The operation then would be as follows with both machines carrying minimum load and the selector switch in position 1: on increasing the load, an impulse from the regulator is routed through to No. 1 governor motor.

After the load has increased to the point where the primary valve is wide open, the auxiliary switch on this valve makes contact energizing the forward control of the selector switch driving motor on the next raising impulse. The selector switch rotates in the forward direction until cut off by the forward contact breaking the circuit with the first contact. The width of the forward and backward contacts are such that the motor will drift to the next position after the control circuit is broken. The switch now is in position 2 and the raising or lowering impulses are still routed to No. 1 governor motor. In the same manner, the selector switch transfers to the next position after the secondary valve on machine No. 1 opens fully. With decreasing load the selector switch returns, the motor being energized through the "backward" selector switch arm and the valve switch contacts which are closed when the valves are closed. The forward and backward auxiliary relays seal in so that the selector switch travels at least one

position and also breaks the control circuit from the regulator so that control is broken during the transfer.

Operating Experiences

The instantaneous speed of any system is a function of the system load and of the setting of the turbine governors; hence, with any given setting the speed of the system will vary as the load changes. If two systems are interconnected through one or more lines, the speed of the entire interconnection becomes a function of all the governors and of the total load; the generator load does not bear a direct relation to the demand on that particular system, but since it is a function of system speed, the excess demand must be supplied through the interconnecting tie lines.

If the two systems under control are of the same size and have approximately the same load characteristics, it is possible for them to remain in parallel for reasonable periods of time when operating on straight speed-governor control without overloading the tie lines. In such interconnections, it is customary for the system controlling the tie line to adjust its governors to maintain 60-cycle frequency if this correction will tend to correct the tie-line loading. With frequency control on one system, all of the load changes occurring on the entire interconnection obviously will appear eventually on the units under automatic control, so that all the net load changes of the system without frequency control will appear in the tie line.

Observation on the Colfax-Springdale tie line for a period of two years has shown the foregoing reasoning to be correct. It is generally assumed that tie-line load control tends to make frequency control more difficult to obtain. This is based upon the assumption that all load changes on one system must flow over the tie line and be compensated for by the frequency-control equipment before the tie-line equipment has functioned. That is to say, the load change is corrected first by the frequency regulator and later by the tie-line control, which in turn requires that the frequency regulator drop an amount of load equal to that picked up by the tie-line load control. This reasoning would be sound if the frequency-control equipment were much faster in response than the tie-line regulator. As a matter of fact, experience has shown that the two types of control work together satisfactorily although possibly at the expense of increased frequency of operation during some periods.

It has been observed also that the use of tie-line regulators affects the permissible neutral zone of the frequency regulators on the interconnected systems. The initial installation of tie-line load control at Colfax was made at a time when the West Penn company was maintaining its system frequency to within ± 0.05 cycle by means of automatic frequency control devices at its Windsor station. Later, in order to reduce the overloading of other tie lines, the frequency was allowed to vary as much as ± 0.15 cycle. This resulted in a more erratic power flow over the tie line and an increase in corrective operation of the tie-line regulator. It is felt that while the solution to tie-line load swings may be put off temporarily by allowing frequency to drift, eventually system speeds will have to be held rigidly at 60 cycles and load control adopted on all tie lines to permit maximum utilization of existing transmission facilities between the interconnected systems.

Another interesting observation has been the effect on the normal band of power swings with manual and with automatic control, respectively. This comparison is shown in Fig. 10. Under manual control the average load drifts without any appreciable change in the width of the band of power swings; whereas with automatic control the average load is maintained very close to the desired amount, but the band of power swings is enlarged greatly.

In October 1930 tests were conducted by the Duquesne and West Penn companies to determine the rate of response of the tie-line control and of the frequency control to rapid load changes. This was accomplished by rapidly lowering the load on the Colfax station 30,000 kw. and allowing the load and frequency controllers at the Colfax and Windsor stations, respectively, to correct the load distribution and frequency without manual assistance. In order to analyze the instantaneous load shifts which ensued, high speed test meters were used; the results of two typical tests are shown in Fig. 6. In both tests, when 30,000 kw. was dropped at Colfax the power flow over the tie line increased almost simultaneously and at the same rate as the load was dropped. This initial division is a characteristic of interconnected systems when the load change occurs at the end of the tie line opposite from the point of frequency control. Without tie-line control the Windsor station being under frequency control would have picked up the entire 30,000 kw. dropped. However, the curves show that in both cases the tie-line load control had accomplished considerable correction by operating on Colfax unit No. 1 before the frequency regulator at Windsor had caused that station to acquire much of the load dropped.

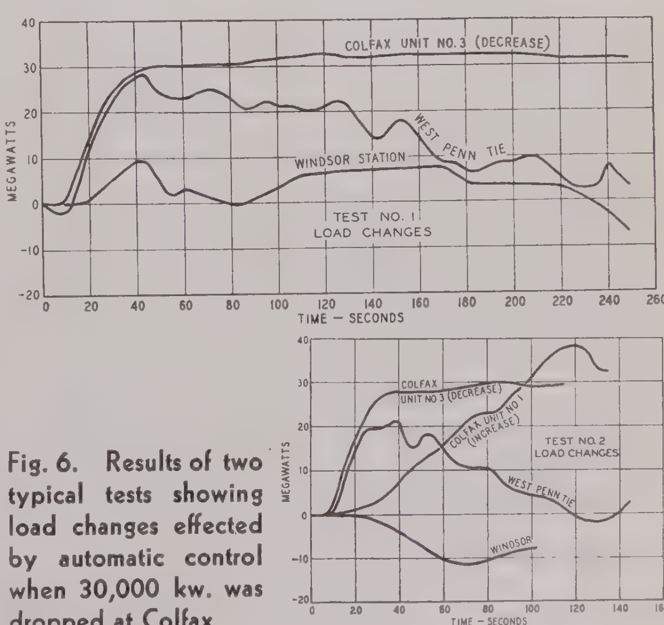

Fig. 6. Results of two typical tests showing load changes effected by automatic control when 30,000 kw. was dropped at Colfax

Both tests were similar except that the speed of response of the load regulator was increased in test No. 2. It may be noted that in this second test the load was dropped at Colfax station but was not picked up at Windsor. This was due to the latter station dropping load faster to compensate for load changes on its own system, and incidentally is a good illustration of the advantages of load diversity through interconnection.

Conclusions

On the basis of the foregoing, it may be said that:

1. Automatic tie-line load regulators and program loading equipment have been developed to a commercial stage.
2. Tie-line load regulators on one system can be operated satisfactorily in conjunction with frequency regulators on a connected system.
3. Tie-line control may be used to reduce load fluctuations between interconnected systems.

Variable Ratio Frequency Converter

Two synchronous-induction frequency converters with controllable frequency ratio and full automatic features were chosen to tie a 25-cycle and a 60-cycle system. Consideration of generation, loads, load cycles, and stability of both systems led to the selection of this type of unit.

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COINCIDENT and continual growth of the 25-cycle and 60-cycle systems of the Union Electric Light and Power Company created a series of problems which called for simultaneous solution. These requirements were essentially:

1. Need for additional 60-cycle prime capacity to meet a normal yearly increment in 60-cycle load.
2. Need for additional 25-cycle reserve capacity to supply overgrowth of a 25-cycle system load beyond the ability of a run-of-river hydroelectric plant and a small 25-cycle steam reserve plant to adequately handle it.
3. Recovery of annual loss of 60,000,000 kw-hr. in run-of-river hydroelectric plant due to deficiency in 25-cycle system load at times.
4. Need for 40,000 kva. in synchronous condenser capacity at St. Louis to operate on end of 136-mile, 60-cycle transmission line.
5. Improvement in 25-cycle system operation if a small amount of corrective kva. could be added at St. Louis end.

A coordinated study indicated that more efficient use of the generating ability of both systems would be possible if they were connected by adequate frequency converter capacity, at the same time securing the complete satisfaction of all but the first point above enumerated. Keokuk, while developed to a maximum capacity of 135,000 kw. as a run-of-river, 25-cycle, hydroelectric plant, was limited at times to a maximum capacity of 70,000 kw., so that the requirement of 60-cycle prime capacity could not be met solely by the installation of frequency changer capacity. However, the 60-cycle system, supplied entirely from steam plants, was being augmented by the addition of a huge storage hydroelectric plant at Bagnell, to satisfy the 60-cycle system demand.

Interconnection of two hydroelectric plants of different frequency by frequency converters has obvious advantages, but when additional system requirements may be satisfied in the same installation with only a minor increase in cost, the importance of such an installation is evident. It was determined that the frequency changers should have the following characteristics:

1. The set should be able to transmit power in both directions in order to provide additional capacity to the 25-cycle system in times of water power deficiency; also access to the 60-cycle system of an additional 60,000,000 kw-hr. annually from the 25-cycle hydroelectric plants. It was found that the transfer to 25 cycles to take care of the load requirements on this system thus could be made without additional investment in 60-cycle generating equipment.
2. The machine should have such characteristics as would provide interconnection between a fixed capacity 25-cycle generating system of 175,000 kw. and an increasing 60-cycle system capacity with a present rating in excess of 450,000 kw.
3. The 60-cycle end of the machine should combine approximately 50,000 kva. of synchronous condenser capacity for use in bringing Osage power into the St. Louis district.
4. Either end of the machine should be constructed to run separately in the event of diversity between the watersheds of the Keokuk plant and Osage plant requiring such operation. This might be required also in the interest of economy in operation.
5. Two machines of one-half capacity each would be preferable to one, because then failure of one machine still would permit adequate operation in most cases.

The required size of frequency converters was determined from load requirements. Two sets of 20,000-kw. rating were chosen as combining most suitably the requirements of load transmittal, spare capacity, and synchronous condenser capacity. The type of set to be used was the subject of considerable investigation. It was found that there were five types of machines available; namely,

1. The synchronous-converter frequency converter
2. The synchronous-synchronous converter

Based upon "Interconnection of the 25- and 60-Cycle Systems of the Union Electric Light and Power Company" (No. 31-137) presented at the A.I.E.E. South West District meeting, Kansas City, Mo., Oct. 22–24, 1931.

3. The synchronous-induction converter
4. The fixed-ratio synchronous-induction converter
5. The variable-ratio synchronous-induction converter

The synchronous-converter frequency converter consists of two synchronous converters on independent shafts, one operating from each of the systems to be interconnected. All power transferred is received at one frequency, converted to direct current and reconverted to alternating current of the other frequency. The fact that this machine has never been built in large sizes definitely precluded its use in this case.

The synchronous-synchronous converter consists of two synchronous machines on a common shaft, one operating on each system. This machine is the one most commonly used. The frequency ratio is fixed and therefore the set constitutes a rigid frequency tie between systems within the limits of pull-out torque of the individual machines. The load is completely reversible, the load transmittal being determined solely by prime mover governing and not controllable at the set. Power factor control of both ends is available over a wider range than in any other type of set. The efficiency is high, preliminary estimates indicating that 95 per cent might be expected on a 20,000-kw. unit. This set is essentially simple in construction and operation and requires but few auxiliary machines. The paralleling of machines requires considerable precision in synchronizing. For example, starting from the 60-cycle end there is only one chance in twenty-four that the machine will "come up" right. Load division between sets is accomplished readily by stator shifting. Since machines of this type in the rating proposed already had been built no untried designs would be necessary.

Records indicated that the reliability of this type of set was good provided the machines were of sufficient capacity to withstand shocks incidental to system disturbances. The chief difficulty in applying this machine lies in determining the proper size of unit required. An examination of data available indicated that not less than from 10 to 25 per cent the capacity of the smaller system would be required. This application would require a set of from 18,000-kw. to 40,000-kw. capacity. Conservatively, it appeared that units of 30,000 to 40,000 kw. each would be required, and since load transmittal requirements did not justify units of this size, this type of converter seemed undesirable.

The synchronous-induction converter consists of a synchronous machine direct-connected to an induction machine of either the wound rotor or squirrel cage type. The frequency ratio of this set varies according to the load on the set and is not controllable at the set. The load is reversible if sufficient synchronous capacity is available to supply the exciting kilovoltampere of the induction machine, but there is considerable change in frequency ratio with change in direction of power flow. Load control is determined by prime mover governing. The set is relatively stable, the stability being determined chiefly by the pull-out torque of the synchronous machine. Power factor control is available on the synchronous end of the set but not on the induction end. The efficiency is relatively low. The set is simple in construction and operation and of good reliability.

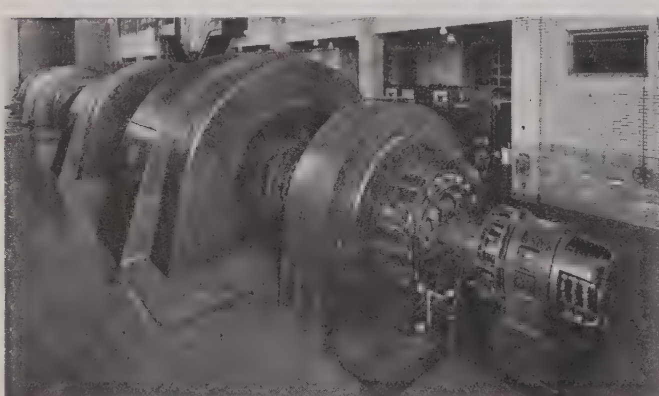
The fixed-ratio synchronous-induction converter consists of a synchronous machine and a wound rotor induction machine with the rotor of the induction machine and the stator of the synchronous unit connected to the lower frequency system, with the stator of the induction machine connected to the system of higher frequency. This converter is sometimes called the "general transformer" since it can be arranged to transform phase, frequency, and voltage. A peculiar characteristic of this set is that it constitutes a voltage tie between systems of different frequencies in a manner analogous to a transformer on a single-frequency system. In several cases the set has been used to obtain certain advantages which this characteristic gives under particular circumstances. In the case at hand this feature was undesirable.

The frequency ratio of this converter is fixed by the design and is rigid. The load is reversible and the load control is obtained by prime mover governing. Stability is good and limited power factor control is available by a combination of transformer tap changing and synchronous machine field control. The efficiency is relatively high and operation is relatively simple although there is only one chance

Two 20,000-kw. variable ratio frequency converters at Page Avenue substation showing starting motor and exciters on 60-cycle end

in ten of correct polarity and phase on the second unit. This type of machine has been reliable in service and has been built in large sizes.

The variable-ratio synchronous-induction converter consists of a synchronous machine direct-connected to a wound rotor induction machine provided with suitable regulating machines, the number and type varying with the particular manufacturer. The distinguishing feature of this set is that the frequency ratio is variable. Voltage and load disturbances are reflected through the set to a lesser degree than with other types. The load is reversible and the load control within the design limits of the set is accomplished at the set itself without dependence on prime mover governing. Stability is good, the maximum load transmittal being determined by the pull-out torque of the synchronous machine, the relative speed changes of the two systems, and the speed of operation of the regulating equipment. It is interesting to note that if the automatic regulating equipment is not working, a relative speed change of twice the slip of the induction machine is required to change from full load in one direction to full load in the other; whereas with fixed ratio types this reversal occurs with only a small phase angle change. In the synchronous machine power factor control can be obtained over a wide range and in the induction machine, over a limited range determined by economic design considerations. Efficiency is good although not so high as on synchronous-synchronous machines; the efficiency varies with variation in frequency ratio. Although simple of operation, the set is somewhat complex. Its main advantages lie in stability, ease of starting, and load control. The sets had been built in the size contemplated and component machines of larger size produced.



The two 20,000-kw. frequency converters, showing the Scherbius regulating equipment for the 25-cycle induction unit in the foreground

Based on this analysis it was decided to purchase two variable-ratio synchronous-induction converter sets, each set to be capable of transmitting 20,000 kw. from the 25-cycle to the 60-cycle system or vice versa with simultaneous and opposite variations in normal frequency of one-half cycle in each system; that is, each set was to be capable of transmitting full load from either system to the other throughout frequency variations from 24.5/60.5 to 25.5/59.5 cycles. This would permit a fairly wide variation of frequency in one system if that of the other were fixed, the range being affected by the direction of load transmittal because of the natural slip of the induction machine.

The machines, completely automatic in operation, are of the six-bearing horizontal type with adequate provisions for movement of stators on both of the large machines to permit easy maintenance or repair. A split coupling is provided between the machines, with the starting motor and d-c. exciters located on the 60-cycle end to permit independent operation of the 60-cycle unit as a synchronous condenser, if required. Each unit occupies an area of approximately 13 x 60 ft. The machines are of the semi-enclosed type, drawing filtered air from the room and discharging it into the basement. The ventilation requirements are 150,000 cu. ft. of air per min. per set.

The frequency converters in several months of operation have met their expected requirements fully. The average over-all efficiency has been approximately 90 per cent during the first six months' operating period, the normal load cycle requiring operation part of the day as 60-cycle generators, and the balance of the time as 25-cycle generators, supplying 25-cycle relay power.

It has been found that the inherent ability of the machine to change load gradually with system speed changes has been of marked benefit in stabilizing the systems. For example, with the set feeding the 25-cycle system, a voltage drop may cause the loss of considerable 25-cycle load with consequent speeding up of that system. The load reverses and the frequency is held to a small departure from normal. The occurrence of a short circuit on the 25-cycle system reduces the exciting voltage to a low value and consequently the decrement curve shows a very rapid drop after the first few cycles; this has the effect of holding the interrupting requirements on oil circuit breakers to a low value. The corrective capacity in the 25-cycle induction units varies from zero at full load to 16,000 kva. at no load and exerts a remarkable stabilizing influence on the 25-cycle voltage. The 60-cycle machines are equipped with high-speed excitation systems so that the 60-cycle voltage is held within close limits.

The machines as installed cannot be operated unless a 25-cycle exciting source is available, although minor modifications would permit d-c. excitation to bring up a dead system. In several cases where the 25-cycle bus voltage has been dropped to a very low value by faults close into the bus, the machines have resynchronized themselves without any difficulty. It is of interest that the voltage of the induction unit is always at the same frequency as the exciting source, but its value may vary through wide limits and it may be considerably out of phase with the system voltage. Consequently, the ability to resynchronize depends upon the action of the regulating equipment and the changes in relative system speeds during the interval when the bus voltage is very low.

Abstracts

Of Papers to Be Presented at the Providence District Meeting

INTERPRETIVE abstracts of all papers which at the time of this issue are definitely scheduled for presentation at the A.I.E.E. Providence District meeting (May 4–7, 1932) are published herewith. Papers presented at this meeting will not be available in pamphlet form, but in response to popular demand and within its space limitations, ELECTRICAL ENGINEERING subsequently may publish certain of these papers, or technical articles based upon them.

The Parallel Type "Inverter"

By
F. N. Tompkins[1]

THE DEVELOPMENT of the thyratron or three-element hot-cathode gas-filled tube with grid-controlled arc has given electrical engineeing a new tool. Many interesting and valuable applications have been devised, among the most interesting of these being the "inverter." Its purpose is the inversion or changing of direct current to alternating current, the reverse process of the more usual rectification. With the advent of the thyratron with its high efficiency, low voltage drop, and its ability to handle the comparatively large amounts of power, the inverter gives promise of becoming of commercial importance.

Inverter circuits may be divided into two main types, series and parallel. While for the former types many data have been published and many different circuits have been devised, very little beyond the fundamental circuit has been given for the latter. The purpose of this paper is to present the results of a study of the parallel-type inverter which was undertaken to secure a better understanding of the function of each part and of the operation as a whole. There is presented the information necessary to make the operation of thyratron circuits understood. The principles of operation of the inverter are developed by means of simple diagrams, and from complete sets of oscillograms the actual operation is shown.

It is demonstrated that the method of operation differs from that usually assumed, inasmuch as the capacitor performs the function of giving the correct phase relation between the input current and the induced transformer primary voltage, rather than providing a sudden reversal of potential on the anode of the tube being stopped. This reversal is provided by the induced primary voltage. The effects of low power factor loads with both leading and lagging current are shown by oscillograms and the effects of improper circuit constants when operating at low power factor are given.

The output wave form under conditions of full load unity power factor is analyzed and it is shown that with the proper circuit constants the voltage wave is a fair approximation of a sine wave. For any given set of circuit constants the output wave forms change with the character and degree of loading. When reasonably good output wave forms are secured, the voltage regulation is poor but the efficiency is high. Changes in the circuit which give better regulation cause poorer wave form so that in the design of this type of inverter circuit a balance must be chosen between these two factors. Curves of efficiency and regulation, the latter showing the effects of different values of capacity, are given and briefly discussed. (Pamphlet copies not available.)

1. Brown University, Providence, R. I.

Engineering Features of Phanotron Tubes

By
H. C. Steiner[2]
A. C. Gable[2]
H. T. Maser[2]

DURING the last few years vacuum tubes have found an ever-enlarging field in industrial applications, the more recent gas filled electron tubes providing the engineer with a tool even better suited to his needs. Among the outstanding engineering features of the gas or vapor filled electron tube (to which the name phanotron has been applied) are as follows:

1. The tubes are static devices, the complete functions of which are performed through the movement of electrons and ions.
2. The efficiency in controlling or converting power is high. Tube efficiency ranges from 95 per cent to over 99 per cent.
3. Control is flexible and the power required for control is small.
4. The speed of operations as a relay is extremely fast, and in addition, the tube may function cycle by cycle or intermittently without the wear that accompanies the operation of mechanical devices.
5. Noise and vibration are entirely absent.
6. Current carrying capacity is available in the range from a few milliamperes to several hundred amperes.

In practise the name phanotron has become associated with the two-element or simple rectifying tube. The phanotron tubes in which the starting of the conduction period is controlled electrostatically by the action of one or more grids have been termed thyratron tubes. The design, characteristics, and operation of these types of tubes are described in this paper, ratings being given

Fundamentally, applications may be divided into two classes; namely, rectifiers converting alternating current into direct current with or without voltage control, and inverters changing direct current into alternating current. Oscillograms are given in the paper for a bi-phase rectifier with voltage control, supplying loads that are predominantly resistive, inductive, and capacitive. The operation of a single phase inverter is described and oscillograms are given for the voltage and current conditions of one of the tubes, the output voltage, and the commutating condenser current. (Pamphlet copies not available.)

Subharmonic Frequencies Produced in Non-Linear Systems

By
W. M. Goodhue[3]

IN BRIDGE measurements, harmonics, due to a non-linear load being measured or due to the power supply may fail to be balanced at the same time the fundamental is balanced. This impresses on the detecting system a wave containing a large proportion of harmonics, or, at true fundamental balance, harmonics without fundamental component. The detecting system contains magnetic materials and may include a vacuum tube amplifier. Different observers have found errors which they traced to the apparent conversion of part of the harmonics into a fundamental component.

It is shown in the paper that a single non-linear device, such as a vacuum tube operating on a curved characteristic, usually converts parts of an input, consisting of third and fifth harmonics only, into a fundamental component. This is distinct from detector action which occurs at the same time and yields a second harmonic, and

2. Genl. Elec. Co., Schenectady, N. Y.
3. Harvard University, Cambridge, Mass.

also from modulation which requires two stages of amplification, one acting as modulator and the other as detector.

For moderate amplitudes, a Taylor's theorem expansion of the characteristic of the non-linear device is employed and resulting formulas for fundamental and harmonics tabulated for an input of two harmonics of arbitrary frequency, magnitude, and phase angle. The Taylor coefficients of the power series expansion which are involved in the resulting formulas are determined graphically, as the graphic method is more informative, less troublesome, and more accurate than attempting to obtain directly the cubic equation by a three point method, etc. The effect studied is essentially a third order effect.

For large amplitudes the method is entirely graphic, and even ordinary methods of wave analysis are not suitable due to the small fundamental and large harmonics. Graphic integration is employed and comparisons made of r.m.s. value, average value, and magnitude of fundamental. Also an example is worked out with an iron alloy (linking a coil) instead of the vacuum tube amplifier. Usually the effect with magnetic materials is further complicated by eddy currents and cyclic loop effects. (Pamphlet copies not available.)

A General Theory of Systems of Electric and Magnetic Units

By V. Karapetoff[4]

GENERALLY it is conceded that the present situation in regard to the electric and magnetic units is far from satisfactory, for the following reasons:

1. Two or three systems of units are in general use (C.G.S. and practical) at least two more are employed by some prominent writers (the Gauss system and the Heaviside-Lorentz system) and new ones are occasionally being proposed.

2. The absolute magnitudes of some units fixed by international agreement or in general use otherwise are considered as being too small or too large by some investigators who urge the adoption of smaller or larger units.

3. There is an appreciable disparity between the "absolute" C.G.S. units and the corresponding "international" units.

4. The physical dimensions of the electric and magnetic quantities are believed by some scientists to be different in different systems of units. Some physicists even believe it legitimate to assign an arbitrary physical dimension to a quantity; as, to assume absolute permeability for any medium to be a numeric.

In this paper it is pointed out that a system of electric and magnetic units may be shown to be characterized by five parameters; namely, a numeric n which gives the ratio between the nominal density of electric displacement used in that system and the true density; a numeric p which gives the corresponding ratio for magnetic flux densities; a physical conversion factor k which converts a given volume of current into the corresponding magnetomotive force; the absolute permittivity κ; and the absolute permeability μ. On the basis of these five parameters, the principal fundamental equations of electricity, magnetism, and electromagnetic waves are written in what is called the general system of units without assigning definite values to these parameters. It is shown also that the five parameters must satisfy the equation $vk = \sqrt{np/\kappa\mu}$ where v is the velocity of propagation of electromagnetic waves in that particular medium to which κ and μ refer; otherwise the five parameters may be chosen artibrarily.

By giving these parameters specific values, seven different systems of units are derived; namely, the electrostatic, the electromagnetic, the practical, the Gauss, the Heaviside-Lorentz, one which the author calls the compromise system, and the ampere-ohm system introduced by him some 20 years ago. The characteristics, the advantages, and the disadvantages of each system are briefly discussed, and it is shown how to deduce a new system of units from the general system.

At the end of the article a discussion is given on the physical dimensions of various electric and magnetic units. It is stated that four fundamental units are necessary for a system so that if certain length, mass, and time intervals are taken as three fundamental units, a fourth electric or magnetic unit must be added, for example, the permittivity or the permeability. In the ampere-ohm system, two mechanical fundamental units are used, the centimeter and the second; also two electrical units, the ampere and the ohm. Physical dimensions of k are unknown. (Pamphlet copies not available.)

4. Cornell University, Ithaca, N. Y.

A Proposal to Abolish the Absolute Electrical Unit System

By E. Weber[5]

THE FUNDAMENTAL discovery that the ratio of the "absolute" electrostatic unit to the "absolute" electromagnetic unit of electric charge, predicted as velocity, was apparently identical with the velocity of light brought about an unforeseen confusion in the field of electrical units. The use of various absolute dimension systems expressing the electric and magnetic quantities by means of the three mechanical fundamental dimensions influenced the writing style of formulas and caused the introduction of arbitrary factors.

A veritable flood of articles and papers has been published in the important periodicals of the world, concerned either with a new system of electric and magnetic units or dimensions, or with a comprehensive basic system of mechanical units. None of them has succeeded as yet, because of the attitude of respect toward the classical "absolute" systems. This paper aims to prove conclusively the incorrectness of these classical dimension systems and to propose "natural systems" which, it is hoped, may finally settle the differences and put the electrical unit systems upon a sound basis.

The absolute dimension systems expressing the electric and magnetic quantities by the three dimensions of mechanics are shown to be incorrect since the consequent use of proper mathematical statements leads to impossible results. However, the definitions of the absolute units, as well as the "practical" units in electromagnetics have a sense quite independent of the dimension systems. It is shown that the simplest and, as it seems, apparently the only true solution is to extend the two mechanical dimensions systems, known as technical and physical systems, into the field of electromagnetics by adding a new fundamental electric dimension. This gives two electrical systems, the electrotechnical dimension system with all the practical units and the electrophysical dimension system with all the absolute units. (Pamphlet copies not available.)

Performance Calculations on Induction Motors

By C. G. Veinott[6]

THE MEANS given in this paper for calculating the performance of both single phase and polyphase induction motors is intended primarily for calculations from previously determined design constants. By actual trial the methods have been found to be very easy to learn and use even without a knowledge of induction motor theory, and are very rapid.

In the past many of the popular calculating methods for induction motors made use of various forms of circle diagrams, charts, families of curves, etc. Both methods developed in the present paper are arrived at by a simple straightforward use of complex algebra, and consist of the filling in of the blank spaces of a calculating sheet especially prepared for this purpose and which can be incorporated on the regular design sheet. The methods are inherently as accurate as the best methods proposed to date, and are more accurate than many of the older methods. Further, they are well suited to rough calculation, ordinary calculation, or exact calculation.

The single phase calculation method is based upon the cross-field theory, the principle being to set up and solve by the algebra of complex quantities three simultaneous equations for the currents in the three circuits of the motor; namely, primary circuit, transformer circuit of the rotor, and the secondary cross-field circuit. The new method is faster than previous graphic methods, and also is more accurate. The independent variable is the rotor speed.

The polyphase calculation method is based upon the equivalent circuit and the equivalent circuit is based upon the revolving field theory. The independent variable is the slip. As it is not necessary to compute the large number of curves required for some of the previous methods, an enormous amount of time and labor is saved. Furthermore, the method distinguishes between primary and secondary leakage. (Pamphlet copies not available.)

5. Polytechnic Institute of Brooklyn, N. Y.
6. Westinghouse Elec. & Mfg. Co., Springfield, Mass.

Measurement of Stray Load Loss in Polyphase Induction Motors

By C. J. Koch[2]

For LACK of a satisfactory method of measurement, no provision is made for stray load losses in the A.I.E.E. standard efficiency tests for induction motors. These losses may amount to from 2 to 5 per cent in squirrel cage motors from 1 to 5 hp. in size, decreasing gradually with increase in motor rating until they are less than 1 per cent for motors of several hundred horsepower. Development of an easy method of measuring stray load losses would not only rectify this situation, but also would permit the losses themselves to be studied more intensively and perhaps ultimately to be reduced greatly.

All methods of measuring stray load losses may be classified as either direct or indirect. Indirect methods aim to measure the total loss in the motor, substraction of the conventional losses yielding the stray load loss. Best known among the various indirect methods perhaps is the input-output method. Direct methods of measuring these losses are based upon the following procedure: Either the rotor or stator winding is excited by direct current with the unexcited winding short-circuited; the rotor then is revolved at synchronous speed and the power required to do this is measured. The stray load loss then is determined by subtracting from the power required to drive the rotor in this manner, the friction and windage losses, and also an amount of power equal to the I^2R loss produced by the fundamental frequency current in the unexcited member.

Upon the basis of a series of tests made on both slipring and squirrel cage motors of different sizes, the following methods are recommended:

Slipring Motors

1. Measure the power required to drive the motor at synchronous speed with the primary winding short circuited and sufficient d-c. excitation applied to the secondary winding to cause full load current to circulate in the primary; designate the power required as W. From the d-c. resistance (making any corrections necessary for differences in temperature) determine the primary I^2R loss and designate this as T.

2. Repeat the test just outlined, with the primary current equal to the magnetizing current, and determine the rotational power required and the I^2R loss; these latter are designated W_o and T_o, respectively.

3. The stray load loss, then, is equal to $W-W_o-T+T_o$.

Squirrel Cage Motors

1. Apply d-c. excitation to the stator using two of the stator terminals and leaving the third open; the amount of direct current required is 1.225 times the full load alternating current per terminal. Under these conditions determine the power required to rotate the rotor at synchronous speed; this is designated W.

2. With the rotor at standstill apply to the stator balanced polyphase voltages of normal frequency and of sufficient value to produce full load current per terminal, and measure the starting torque thus produced. A check on the correctness of the torque obtained is given by the fact that its value expressed in synchronous watts must be somewhat less (usually from 5 to 20 per cent) than the stator watts input less the stator copper loss as calculated from d-c. resistance. Then T = Synchronous watts torque − 0.142 × Syn. Speed (r.p.m.) × Torque (lb.-ft.)

3. Repeat the test just described, determining W_o with d-c. excitation equivalent to normal a-c. magnetizing current and calculate

$$T_o = T\left(\frac{\text{Magnetizing Current}}{\text{Full Load Current}}\right)$$

4. The stray load loss is then equal to $W - W_o - T + T_o$

In practise, the starting torque varies closely as the square of the primary current. It is desirable therefore to measure the value of T at only one value of current, selected to obtain the greatest accuracy of test, and to obtain the values of T at other points by proportionality. The best value of current to select for this test will depend somewhat upon the type and size of motor. If the current is too large, overheating takes place and errors arise due to incorrect determinations of conductor temperature. However, if too low values of current are used, the small torque produced in comparison with the static friction makes accurate values difficult to obtain. It is recommended that full load current normally be used for squirrel cage and ball bearing motors, while values of 150 per cent full load current are recommended for normal use on sleeve bearing motors of less than 25 hp.

It is suggested that, after confirmation or modification by other investigators, the methods outlined be taken as a basis for revision of the A.I.E.E. standards, such revision to require the inclusion of induction motor stray load losses in efficiency determination. (Pamphlet copies not available.)

Torque-Angle Characteristics of Synchronous Machines Following System Disturbances

By S. B. Crary[2]
M. L. Waring[2]

THE DETERMINATION of the behavior of synchronous machines during transient conditions subsequent to a system disturbance is becoming increasingly interesting and important. In determining this behavior it is essential to know the torque-angle characteristic of the given machine under conditions resulting from disturbances of various sorts. The most important of such disturbances are variations in mechanical torque, excitation voltage, amount of external reactance, and system voltage. System voltage may vary in either magnitude or angular position.

Some of these disturbances already have been treated by various authors. It is the purpose of the first part of the present paper to establish general equations from which may be derived specific equations. Starting with the fundamental relations already developed, general equations are derived for the positive phase sequence torque of a synchronous machine subsequent to the following:

1. Switching in or out of a connecting line.
2. Occurrence of a balanced three phase system fault.

The evaluation of the torque characteristics following such disturbances is of particular importance in the determination of transient stability limits, and a step-by-step method of calculation is given so that the electrical torque of a machine having any number of rotor circuits can be determined at any time of its swing. The formulas and step-by-step method presented make it possible to predetermine the effects of amortisseur windings and high speed excitation. No attempts, however, have been made to draw any general conclusions as to the effect of these two factors.

In the second part of the paper an actual case of switching out of a connecting line is calculated, and the results compared with field tests taken on the system of the New York Power and Light Corporation. These tests are described in the companion paper, "Field Tests to Determine Damping Characteristics of Synchronous Machines." Good agreement between the calculations and test results is shown. (Pamphlet copies not available.)

Field Tests to Determine the Damping Characteristics of Synchronous Generators

By F. A. Hamilton, Jr.[2]

PRACTICAL system tests of the damping action of generators with and without low resistance damper windings, but otherwise identical, have been made. The effects of normal variations of generator field circuit resistance, field current, and loading were investigated, and data for checking calculated machine constants also were obtained. The results of the tests presented in this paper are valuable from a quantitative, as well as from a qualitative standpoint.

The field tests proved useful in providing graphic evidence of phenomena not well understood, and in obtaining data to verify available methods of analysis and upon which to build new methods of calculation and extension of existing theory.

Low resistance damper windings were found quite definitely to assist the rapid smoothing out of balanced disturbances resulting from the switching in or out of lines, synchronizing, load changes, or the tripping of loaded generators, and three phase short circuits. The test results indicate that generator field circuit resistance and generator field current may be varied within normal limits without greatly affecting the generator damping characteristics. Also, the test data verified methods of calculation presented in the companion paper, "Torque-Angle Characteristics of Synchronous Machines Following System Disturbances." (Pamphlet copies not available.)

Design of Capacitor Motors for Balanced Operation

By P. H. Trickey[6]

THE PRESENT methods of calculating the full load performance of capacitor motors are quite long and tedious. A simple convenient method of calculating full load conditions is given in this paper, including the necessary theory and formulas.

It is agreed generally that a capacitor motor should be designed to operate under nearly balanced conditions at full load. This means that there shall be no transfer of power from one phase to the other and the rotor current shall be balanced. With such a design, each phase produces equal flux and the rotor operates as if it were in a two phase stator. The theory presented in this paper is based upon balanced conditions, the method being useful only when the starting torque required is not too great. In many cases the starting torque requirements determine the winding, and the motor must operate slightly unbalanced at full load, with the resultant circulating current and lowered efficiency. (Pamphlet copies not available.)

The Electro-Matic Traffic Dispatching System

By H. A. Haugh, Jr.[8]

VEHICLE actuated traffic dispatching systems may be used by which the traffic in a given area controls itself. By this means the duration of the green light period at any intersection is in proportion to the volume of traffic on each approach. A smooth flow of vehicles is produced which uses the intersection efficiently.

This system of traffic control consists of three main parts; namely, the detectors, the signal lights, and the dispatcher. The detector may be any one of several types, such as a mechanical switch located in the pavement, an electromagnetic unit, or a beam of light which will be interrupted by approaching vehicles. The mechanical type has been found to be the most practical.

This dispatching device for this type of system must be of extreme flexibility, and the timing of the signal light cycle must constantly change to meet the irregular demand of traffic. This operation is secured by a group of time-delayed relays, combined with a switching mechanism. The resulting operation is similar to that which would be secured by having a traffic policeman at each corner, and the speed and amount of traffic, length of time which a car has to wait, and such factors, all are taken into consideration. The right-of-way is yielded to cross street traffic when the intersection is clear, and even when it is not clear if the cross traffic has waited for a predetermined period. However, moving traffic is never interrupted unless the right-of-way has been called to the cross street by waiting traffic or by a "pedestrian period." (Pamphlet copies not available.)

The Flexible Progressive Traffic Signal System

By H. I. Turner[7]

A FLEXIBLE progressive traffic signal system usually makes it possible to time signals so that traffic may move east and west, as well as north and south, at predetermined uniform speeds without being obstructed by a "stop" signal after once having passed a "go" signal. The planning of such a system is a matter that requires most intelligent study and one which yields results well worth the effort. Traffic-actuated equipment seldom can be justified over pre-timed equipment, as in a great majority of congested districts the coordination of the movement of traffic through the entire district is of incomparably greater importance than the most efficient movement of traffic at any few intersections taken by themselves.

Two general types of systems are used for planning service: the first employing a central office type controller with no timing devices located at the individual intersections, and the second, that which employs a master controller at a center point and an individual controller at each intersection. All of these controllers must have facilities for adjusting the time of each cycle of operation of the signals at any intersection from a central point, the percentage of the cycle taken by "go" and "stop" signals must be adjustable over a wide range and independently, and the start of the cycle of operation at any one intersection should be completely adjustable.

The following features are important in any flexible progressive control device:

1. Minimum maintenance expense and service interruptions.
2. Facilities for manual control.
3. Facilities for shutting down the signals at each local controller and from a central point by merely throwing a switch.
4. Adjustments which can be understood easily and made over a wide range.
5. The duration of the amber light should not increase or decrease when the total time cycle is changed.
6. Means should be provided for exhibiting emergency signals by control from a central point.
7. Means should be provided for accommodating traffic during times of the day when it is very heavy on a particular street. (Pamphlet copies not available.)

A Recent Development in Traffic Control

By H. W. Vickery[9]
V. W. Leonard[9]

A TIMING device containing new features and having extremely wide ranges of adjustment recently has been developed as a means for meeting the problems encountered in controlling present day vehicular traffic.

In the timer, a means is provided to give three progressive relations of the signals; thereby, the progressive relation can be changed remotely to give, for example, ideal progression of traffic into a city in the morning, and out in the late afternoon, with average progression in both directions at other hours of the day.

The timer is driven by a synchronous motor. Thus, accuracy of timing and timer settings is assured. A gear shift unit in which the gears can be shifted manually or from a remote point gives provision for changing the total time cycle. A solenoid operated drum containing a predetermined arrangement of cams opens and closes the signal light circuits. Any of the modern color sequences can be obtained by proper arrangement of the cams on the drum. Momentarily, by keys in a cycle percentage dial, a revolving switch is closed a given number of times each cycle. Thus, impulses are supplied to the drum solenoid and the drum is advanced through the various periods of the color sequence. By proper arrangement of the keys any desired percentage adjustment of these periods can be obtained.

A multi-contact relay in each timer, operated over the same wires used for remote shifting of the gears, gives provision for remote control of shut down, flashing amber, and fire control. (Pamphlet copies not available.)

The Traffic Flow Regulator

By C. H. Bissell[10]
J. G. Hummel[10]

THE PRACTISE of assigning a definite period for the red and green lights of each traffic signal, and keeping these periods constant throughout the day and week, is subject to serious criticism. Needless delays and congestion are caused, and the obedience of motorists to traffic signals in general may be broken down.

Traffic surveys have demonstrated that there are very definite traffic peaks and valleys for each week day as well as for Saturdays

7. Eagle Signal Corp., Moline, Ill.
8. Automatic Signal Corp., New Haven, Conn.
9. Genl. Elec. Co., W. Lynn, Mass.
10. Crouse-Hinds Co., Syracuse, N. Y.

and Sundays. Experience has shown that these variations occur with definite regularity. It has not been found practical or economical to send out officers to change the timing on every signal light. Also, the system of some sort of an electrical or mechanical device to record the amount of traffic and adjust the timing signals accordingly, entails an expense which cannot be justified.

A traffic flow regulator has been developed to vary the timing automatically through any predetermined cycle. For example, the device may be set to give a different signal at each of a large number of periods throughout the day, and the setting may be varied for different days of the week. In addition, certain special conditions frequently are encountered, and for these the timing device allows compensation. A system of extreme flexibility is thus secured. (Pamphlet copies not available.)

Double Conductors for Transmission Lines

By H. B. Dwight[11] E. B. Farmer[11]

FOR OVERHEAD transmission lines, double conductors, consisting of a second conductor hung a few inches below the first by metallic hangers, present a number of advantages over one larger conductor. With this double construction, the two conductors are electrically in parallel and form one effective conductor of large cross-section without increasing the number of insulators or crossarms. In some cases where there is a mechanical margin of safety, it may be found desirable to add a second conductor to the present single conductor.

Among the advantages which may be secured by the use of double conductors are: a reduction of 20 per cent or more in reactance, almost entire elimination of skin effect, an increase in current carrying capacity of nearly 30 per cent, an increase in corona voltage of from 10 to 25 per cent, and in some cases the opportunity to add to the conductivity and power rating without scrapping the old conductor. The advantages are to be balanced against the extra cost due to mechanical features including hangers, increased cost of stringing, and additional wind and ice load. Since the increase in ice load is possibly the greatest disadvantage, the use of double conductors is of greatest interest to southern districts where ice load is not encountered.

In this article, formulas are given for the calculation of the electrical characteristics of double conductor transmission lines, which enable comparisons with other types to be easily made. (Pamphlet copies not available.)

Three Phase Multiple Conductor Circuits

By Edith Clarke

DURING the past year, the subject of power transmission by multiple conductor circuits has received considerable attention. Therefore the formulas and estimating curves given in this paper may be of interest.

Formulas are developed for the inductance and capacitance to neutral per phase and the approximate corona starting voltage of perfectly transposed multiple-conductor three-phase transmission lines having any number of conductors per phase.

For certain special arrangements of the conductors, curves are given for the 60-cycle reactance, capacity susceptance, and corona starting voltage. Throughout their practical range these curves show the effect of variations in conductor diameter, spacing between phases and between conductors of the same phase. Two, three, four, and five conductors per phase are considered.

A comparison is made of multiple and single-conductor circuits with respect to charging current, voltage at no load, power which can be carried with the same voltage drop, and stability. (Pamphlet copies not available.)

11. Mass. Inst. of Tech., Cambridge, Mass.

The Solution of Circuits Subjected to Traveling Waves

By H. L. Rorden[12]

THE EFFECT of traveling waves upon terminal apparatus usually is most easily solved by means of Heaviside's operational calculus. Solutions have been given previously for various combinations of impedances that may be encountered in service, by considering such impedances to be contained in simple circuits. These are intended to approximate the general conditions of a transmission system. However, a purely mathematical analysis of such an involved nature often is looked upon skeptically and experimental variation of such calculation therefore is valuable.

It is the major purpose of this paper to illustrate the accuracy with which mathematical solutions of traveling wave theory are substantiated by test results. For this purpose a transmission about 2 miles long was used, this line consisting of parallel conductors placed 8 ft. apart and forming a loop so that both ends terminated at the laboratory where both the lightning generator and the cathode ray oscillograph were located. Various other arrangements were used including the direct application of the lightning waves to impedances and transformers.

Much valuable information has been obtained relative to the wave shape and other peculiarities of traveling waves. Many irregularities exist in these waves, but generally the waves may be reproduced to a sufficient degree of accuracy that their effect may be determined both analytically and experimentally. It was found that in general the test results checked the calculations very precisely. The relative importance of the various factors affecting traveling waves also are discussed, and it is pointed out that certain of these may be neglected. (Pamphlet copies not available.)

Corona Limit, Transmission Characteristics, and Method of Loading Multiple Conductor Lines for Very High Voltages

By C. A. Boddie[13]

THE OBJECTS of this paper are to discuss a simple and practical method by which the present transmission voltages may be increased greatly and to point out a method of avoiding the detrimental effects of the immense charging currents attendant on the use of very high voltages. The most formidable natural limitation which prevents raising line voltages is the formation of corona, and the paper is concerned chiefly with the overcoming of this limitation. This may be accomplished by the proper method of increasing conductor diameter and using multiple conductors. The conclusions brought out by this paper are as follows:

Transmission lines may be built for considerably higher voltage than those at present used, and the same economies available through the use of higher voltages apply to voltages above 220 kv. as apply below that value. No very serious difficulties may be expected in going to the higher voltages. Multiple conductor lines lend themselves naturally to use at very high voltages, and line charging currents may be taken care of easily by introducing air gaps in the raising and lowering transformers or by use of properly designed loading coils. Also, loading coils assist greatly in switching.

When large blocks of power are to be transmitted it is always most economical to push the line voltage up to the point where a single circuit will transmit all the power. This may always be done however great the power. The question of duplicate lines as affecting the continuity of service may in some cases tend to modify this conclusion, but in general the fewest possible number of circuits gives the most economical system. Improvement in the methods of operating large three phase lines will minimize the necessity for spares and emphasize the foregoing conclusion. (Pamphlet copies not available.)

12. Genl. Elec. Co., Pittsfield, Mass.
13. Boddie Electro Physical Laboratories, Wilkinsburgh, Pa.

News

Of Institute and Related Activities

North Eastern District to Meet at Providence

THE EIGHTH annual meeting of the North Eastern District of the A.I.E.E. will be held at Providence, Rhode Island, May 4–7, 1932, with headquarters at the Providence Biltmore Hotel. The committee has arranged an attractive program consisting of four technical sessions, inspection trips, a banquet, entertainment features, and a special program for the ladies. Another important feature of the meeting will be the student program scheduled for Friday, May 6. The technical sessions cover a variety of subjects. There will be a symposium on traffic control, a session arranged by the committee on electrical machinery, one by the committee on power transmission and distribution, and a session on selected subjects.

Providence, the capital of Rhode Island and the southern gateway to New England, enjoys exceptional shipping facilities to all parts of the world. Situated at the head of Narragansett Bay, 30 miles from the ocean, it occupies a strategic position as a port for both foreign and domestic commerce as well as a point of inland distribution; it is the second largest oil distributing port on the Atlantic seaboard. The city, itself, has a population of approximately 350,000, and within 15 miles of the city hall there are more than 700,000 inhabitants. The community enjoys 59 parks and playgrounds, the Roger Williams Park with its chain of lakes being considered one of the most beautiful parks in the country.

Providence is the home of Brown University established in 1664 and seventh in age among American colleges with an enrollment of approximately 2,200 students and a faculty of 200. Pembroke College for women is a part of the university. Providence College, the Rhode Island College of Education, the R. I. School of Design, and the R. I. College of Pharmacy all are located here. R. I. State College is at Kingston.

Industrially, Providence ranks high; it is the center of a state which has 55.1 per cent of its workers engaged in machine trades. The Brown and Sharpe Mfg. Co., makers of tools, the Nicholson File Co., American Screw Co., and Gorham Mfg. Co., makers of sterling silverware, all located in this city, are the largest in the world in their respective fields. The rubber industry also has good representation by seven large plants producing rubber footwear, medical goods, and novelties. Some of the largest plants of the U. S. Rubber Company are located here.

South Street generating station of the Narragansett Electric Company, Providence, one of the largest steam plants in New England. The installed generating capacity is 225,000 hp.

The Narragansett Electric Company, largest unit in the New England Power Association, serves most of the entire central and southern sections of the state, the southern part being served through a subsidiary company, the South County Public Service Company. The Blackstone Valley Gas and Electric Company serves the northern section and the Newport Electric Corporation the islands of Rhode Island and Conanicut. A network of transmission lines, steam and hydroelectric stations give to Rhode Island the benefit of an abundant supply of electric current. The Providence Gas Company established in 1848 serves about 82,000 customers in Providence and suburbs.

Entertainment Features

Wednesday night will witness the "Gathering of the Clans." Provision will be made for informal get-togethers and reunions, card tables will be available, and supper dancing may be enjoyed in the Venetian Room of the Providence Biltmore Hotel.

Sock and Buskin, the dramatic organization of Brown University, is endeavoring to arrange a performance on Friday evening for the Institute members and ladies.

To the golf playing members there will be available the facilities of the Wannamoisett Country Club, a ranking course over which the Professional Golfer's Association in 1931 played off their championship. Tennis facilities will also be provided.

Banquet

The banquet will be held Thursday evening in the main ballroom of the Biltmore. Prof. William H. Kenerson of the mechanical engineering department of Brown University will act as toastmaster and William S. Lee, junior past-president of the Institute, will be the speaker of the evening. Both President C. E. Skinner and Vice-President I. E. Moultrop will address the meeting, and the District prizes awarded for papers given in 1931 will be presented. At the conclusion of these ceremonies there will be dancing until 1:00 a.m.

Ladies' Entertainment

The committee for the entertainment of the ladies has prepared what should be an interesting program. It is planned to spend one afternoon in colonial Rhode Island, a large share of which still maintains its original appearance. This will be rounded out with a tea in the historic mansion now housing the Handicraft Club. A luncheon and bridge at one of the city or nearby country clubs also is contemplated. Trips to Roger Williams Park and other points of local interest will be arranged. Golf courses and tennis courts will be made available

to all ladies interested in those departments of sport.

Inspection Trips

Inspection trips are scheduled on the program for Thursday afternoon and Saturday morning. In addition, a special trip for the students is being arranged for Friday afternoon.

Full details of all trips will be announced later and posted on the bulletin board. Among the places of interest which may be visited are a generating station and substations of the Narragansett Electric Company and the Gorham Manufacturing Company. The engineering laboratories of Brown University will also be open for inspection. Several other trips also are being arranged.

Registration

All who plan to attend the meeting should register in advance by mail. A card for this purpose will be sent to all members of Districts 1 and 3 before the meeting. Members should complete their registration after arrival at the meeting so as not to miss the opening session. There will be a meeting fee of one dollar for members and fifty cents for students.

All who register in advance will be sent a road map of Rhode Island and a map of the downtown section of Providence showing headquarters and convenient parking and garage facilities.

Hotel reservations should be made by writing directly to the hotel preferred. Rates for the headquarters hotel, Providence Biltmore, as well as several other recommended hotels are given in the accompanying table.

Technical Program

Abstracts of all papers to be presented at the meeting are given on adjoining pages. Pamphlet copies of these papers are not available.

All technical sessions and the opening of the meeting will be held at the Providence Biltmore Hotel. Breakfast meetings will be announced on the bulletin board near registration headquarters and will be held daily for authors and chairmen of the technical sessions scheduled for the day.

Wednesday, May 4

9:00 a.m.—Registration

9:30 a.m.—Opening Session

Opening address—I. E. Moultrop, vice-president, North Eastern District, A.I.E.E.

Welcoming remarks—James E. Dunne, mayor of Providence

Greetings—Leighton T. Bohl, president of Providence Engineering Societies

Selected Subjects—Prof. V. Bush, *chairman*

Parallel Type Inverter, F. N. Tompkins, Brown University

Engineering Features of Phanotron Tubes, H. C. Steiner, A. C. Gable, and H. T. Maser, General Electric Co.

Subharmonic Frequencies Produced in Non-Linear Systems, W. M. Goodhue, Harvard University

A General Theory of Systems of Electric and Magnetic Units, V. Karapetoff, Cornell University

A Proposal to Abolish the Absolute Electrical Unit Systems, E. Weber, Brooklyn Polytechnic Institute

2:00 p.m.—Electrical Machinery—P. L. Alger, *chairman*

Performance Characteristics of Induction Motors, C. G. Veinott, Westinghouse Electric & Mfg. Co.

Stray Load Loss in Polyphase Induction Motors, C. J. Koch, General Electric Co.

Torque-Angle Characteristics of Synchronous Machines Following System Disturbances, S. B. Crary and M. L. Waring, General Electric Co.

Field Tests to Determine the Damping Characteristics of Synchronous Generators, F. A. Hamilton, General Electric Co.

Design of Capacitor Motors for Balanced Operation, P. H. Trickey, Westinghouse Electric & Mfg. Co.

8:00 p.m.—Informal Reception

Thursday, May 5

9:00 a.m.—Symposium on Traffic Control—H. M. Turner, *chairman*

Address: The Broader Aspects of Traffic Control, E. P. Goodrich, president, Traffic Institute

The Flexible Progressive Traffic Signal System, H. I. Turner, Eagle Signal Corp.

Electromatic Traffic Dispatching System, H. A. Haugh, Jr., Automatic Signal Corp.

Recent Developments in Traffic Control, H. W. Vickery and V. W. Leonard, General Electric Co.

Traffic Flow Regulator, C. H. Bissell and J. G. Hummel, Crouse-Hinds Co.

12:00 m.—District Executive Committee Luncheon

2:00 p.m.—Inspection Trips

6:00 p.m.—Banquet

Friday, May 6

9:00 a.m.—Student Technical Session

Address—William S. Lee, junior past-president, A.I.E.E.

Awarding of Prizes

12:00 m.—Luncheon Conference of Counselors and Delegates

2:00 p.m.—Student Inspection Trip

2:00 p.m.—Transmission—P. H. Chase, *chairman*

Double Conductors for Transmission Lines, H. B. Dwight and E. B. Farmer, Massachusetts Institute of Technology

Three Phase Multiple Conductor Circuits, Edith Clarke, General Electric Co.

The Solution of Circuits Subjected to Traveling Waves, H. L. Rorden, General Electric Co.

Corona Limit, Transmission Characteristics and Method of Loading Multiple Conductor Lines Designed to Operate at Very High Voltage, C. A. Boddie, Boddie Electro Physical Labs.

7:30 p.m.—Entertainment Feature
(To be announced at the meeting)

Saturday, May 7

Meeting rooms have been arranged for continued sessions of any part of the technical program.

The local committee is planning an all-day trip, details of which will be announced later.

Rules on Presenting and Discussing Papers

At the technical sessions papers will be presented in abstract, ten minutes being allowed for each paper unless otherwise arranged or the presiding officer meets with the authors preceding the session to arrange the order of presentation and allotment of time for papers and discussion.

Any member is free to discuss any paper when the meeting is thrown open for general discussion. Usually five minutes is allowed to each discusser. When a member signifies desire to discuss papers on other subjects or groups he shall be permitted a five-minute period for each subject or group.

It is preferable that a member who wishes to discuss a paper give his name before hand to the presiding officer of the session at which the paper is to be presented. Copies of discussion prepared in advance should be left with the presiding officer.

Each discusser is to step to the front of

The Mall—heart of the business section of Providence—looking toward the city hall from the steps of the Federal Building. The Providence Biltmore Hotel is on the right, the Union station being slightly further to the right

the room and announce, so that all may hear his name and professional affiliations.

COMMITTEES

District Meeting—I. E. Moultrop, *chairman*, vice-president, North Eastern Dist.; A. C. Stevens, secretary-treasurer, North Eastern Dist.; C. W. Henderson, chairman, Student Counselors, North Eastern Dist.; O. W. Briden, R. W. Graham, W. S. Maddocks, J. P. McCann, R. G. Warner, and F. C. Young.

Local—W. S. Maddocks, *chairman;* O. W. Briden, *secretary-treasurer;* R. W. Herrick, Mrs. R. W. Herrick, J. W. Keeney, L. P. Kenneally, and J. C. B. Washburn.

Hotels and Registration—O. W. Briden, *chairman;* R. W. Allen, L. P. Breault, A. S. Kirk, E. E. Nelson, R. C. Patton, O. E. Sawyer, F. N. Tompkins, and R. J. Underwood.

Finance—J. W. Keeney, *chairman;* W. W. Broadbent, and O. W. Briden.

Inspection Trips and Transportation—J. C. B. Washburn, *chairman;* P. W. Browers, P. L. Carroll, E. B. Curdts, R. W. Eaton, L. E. Fogg, J. E. Hall, C. H. Parker, and G. U. Parks.

Sports, Entertainment, and Banquet—R. W. Herrick, *chairman;* E. S. Esty, M. V. Gardner, I. W. Knight, J. J. O'Brien, W. C. Slade, T. G. Webber, and J. W. Young.

Student Program—C. W. Henderson, *chairman;* W. B. Hall, and L. W. Hitchcock.

Publicity—L. P. Kenneally, *chairman.*

Ladies Entertainment—Mrs. R. W. Herrick, *chairman;* Mrs. R. W. Eaton, Mrs. W. S. Maddocks, Mrs. W. C. Slade, and Mrs. J. W. Young.

Hotel	Single	Double
Providence Biltmore	$3.50–$7.00	$5.50–$10.00
(With bath and shower)	$5.00–$8.00	$7.00–$12.00
Narragansett	$2.50*	$4.00*
	$3.00–$3.50	$4.50–$5.00
Crown	$2.00*	$4.00*
	$3.00	$6.00
Wayland Manor (Family Hotel)	$3.50	$5.00
Apartments, 3 or 4 persons, $2.50 per person		

* Rooms without bath.

Great Lakes District Milwaukee Meeting Exceeds Expectations

As a fitting tribute to the various committees that planned and handled the meeting of the Great Lakes District (No. 5) held at the Pfister Hotel in Milwaukee March 14–16, the attendance and participation in the meeting activities exceeded even the fondest expectations of those in charge of the work. The whole program of activity for the meeting was well conceived, and organized for the greatest convenience of those attending. Technical sessions were held only in the forenoons, Monday, Tuesday, and Wednesday, with the single exception of the student technical session which was held Monday afternoon. An attractive and carefully managed program of inspection trips provided those in attendance with afternoon activities which served as recreation as well as to acquaint the participants with the interesting features of Milwaukee industries. The popularity of this program was emphatically attested to by the registration of 552 members, Enrolled Students, and guests.

With credit to T. N. Lacy of Detroit, Mich., and to A. G. Dewars of Minneapolis, Minn., respectively vice-president and secretary for the Great Lakes District, for the coordination of District activities in connection with the meeting, full credit for the untiring prosecution of the details so essential to meeting success, goes to F. A. Kartak, dean of engineering of Marquette University, Milwaukee, vice-chairman of the District meeting committee, and to the committee organization which functioned under his direction. The general committee, in addition to those already mentioned, included C. C. Knipmeyer of Terre Haute, Ind., student counselor for the Great Lakes District; J. F. H. Douglas, Fraser Jeffrey, C. H. Krueger, and E. U. Lasson, of Milwaukee, Wis.; F. R. Innes and F. H. Lane, of Chicago, Ill.; N. H. Blume and L. C. Larson, of Madison, Wis.; and C. E. Skroder of Urbana, Ill.

TECHNICAL SESSIONS

The Milwaukee technical program consisted of sixteen papers divided among three sessions held one each morning. For the most part these sessions were operated on a strict schedule so as to balance the time between presentation and resulting discussion. This program control contributed to the effectiveness of the sessions, all of which were heavily attended (as high as 300 persons per session). In so far as possible papers were grouped on the program according to their subject matter and expected appeal.

One effort which undoubtedly contributed in an important way to the smooth and effective handling of the various technical sessions was the holding each morning, preceding the session, of a breakfast meeting presided over by the chairman of that day's session and attended by all persons involved in the presentation of papers for that session. At these informal conferences last minute details involving the coordination of presentation and discussion were worked out to mutual satisfaction, and any special contingencies taken care of, all to the benefit of the session itself. The technical program was under the direction of Prof. J. F. H. Douglas, whose committee comprised L. R. Mapes and H. E. Wulfing, of Chicago, Ill., E. Bennett of Madison, Wis., B. H. Clingerman of Minneapolis, Minn., G. E. Lewis of Ann Arbor, Mich., and S. H. Mortensen and G. G. Post of Milwaukee, Wis.

STUDENT PROGRAM

The student program, in addition to active student participation in all meeting activities, included a Monday morning executive session of the student activities committee under the chairmanship of Prof. C. C. Knipmeyer, student counselor for the Great Lakes District. At that session there was 100 per cent attendance of Student Branch chairmen from the sixteen Branches in the district. Each chairman gave a report covering the year's work of his branch, and also outlined plans and problems involved in future activities. An open forum discussion resulted in a highly desirable interchange of ideas.

The student technical session held Monday afternoon was attended by 225 Enrolled Students, comprising an excellent representation from each of the District's sixteen Branches. Ten excellent technical papers prepared by nineteen student authors were presented during the afternoon's session. Interest was so intense that all present remained throughout the entire afternoon for the presentation of the whole group of papers, maintaining the closest attention throughout the session. The 150 mimeographed copies of each of the ten papers that were available for distribution at the meeting failed to meet the demand. Papers presented included the following:

1. THE ELECTRON TUBE IN THE MODERN WORLD, F. M. Deerhake, University of Illinois.
2. OPPORTUNITIES IN HOME LIGHTING, D. W. Marchant, University of Iowa.
3. LOW VOLTAGE A-C. DISTRIBUTION NETWORKS, O. J. DeBever, Lewis Institute.
4. MAGNETIC TESTS OF COLD ROLLED STEEL, GREY CAST IRON AND CHROME-NICKEL CAST IRON AT HIGH FLUX DENSITIES, E. Halbach, H. VanPietersom, C. R. Dernbach, C. G. Post, C. R. Mikolic, M. J. Auchter, R. G. Klein, and H. A. Trimborn, Marquette University.
5. DISTRIBUTION OF ELECTRICITY FOR LIGHTING OF BUILDINGS, L. Zanoff, University of Michigan.
6. RESONANCE IN A NON-LINEAR CIRCUIT, R. T. Bozak, School of Engineering of Milwaukee.
7. AN EXPERIMENTAL STUDY OF INDUCTION MOTOR LOSSES, E. S. Loye, and L. A. Rovelshy, University of Minnesota.
8. TELEVISION, AN INVENTION IN THE MAKING, E. M. Purcell, Purdue University.
9. DIBUTYL PHTHALATE AS A SUBSTITUTE FOR TRANSFORMER OIL, J. W. Niemi, and J. H. Montgomery, Rose Polytechnic Institute.
10. RECTILINEAR GRAPHS, H. E. Grant, University of Wisconsin.

Monday evening a special student dinner was served at the Marquette Union, followed by suitable brief addresses and a lively St. Patrick's celebration under the auspices of the local Student Branches. Prof. C. C. Knipmeyer in charge of student program, was ably assisted by E. W. Kane and V. M Murray of Milwaukee.

ENTERTAINMENT FEATURES

Active in supporting Milwaukee's reputation for hospitality, the various committees that promoted and handled the inspection trips, the women's activities, and the dinner-dance program provided those attending the meeting with more than they could do within the allotted time. These activities were well conceived and carefully and smoothly fitted into the general program for the Milwaukee meeting. Inspection trips, available each afternoon, embraced local industrial and municipal undertakings of a scope sufficiently wide to meet the desires of the most critical. Transportation was supplied by the local committee for trips *en masse* for the larger and more popular trips, and transportation for small parties wishing to make trips of a special character. This feature of the program was under the direction of W. F. Lent of Milwaukee, whose committee consisted

of C. W. Kuhn, J. A. Potts, L. F. Reinhard, and R. C. Siegel, of Milwaukee.

Inspection trips included the plants of Allis-Chalmers Manufacturing Company, Falk Manufacturing Company, Cutler-Hammer Inc., Westinghouse Lamp Company, and the O. A. Smith Corporation; properties of The Milwaukee Electric Railway & Light Company and the Wisconsin Telephone Company; and the Milwaukee sewage disposal plant.

Activities planned for the women and carried out under the direction of Mrs. J. D. Ball of Milwaukee included shopping trips, sightseeing trips, and bridge and theater parties. Organized activities were supplemented by provisions to take care of special desires of smaller groups. Assisting Mrs. Ball were: Mrs. S. C. Fraser, Mrs. Fraser Jeffrey, Mrs. E. W. Kane, Mrs. F. A. Kartak, Mrs. V. M. Murray, Mrs. A. Simon, Mrs. C. H. Skinner, Mrs. R. B. Williamson, Mrs. S. H. Mortensen, and Mrs. E. W. Seeger.

A fitting climax to the entertainment side of the program was furnished by the informal dinner-dance held Tuesday evening under the direction of Prof. John D. Ball of Milwaukee, and his hard-working committee: F. A. Coffin, S. C. Fraser, J. A. Havlick, R. G. Lockell, O. W. A. Oetting, C. H. Skinner, Sam Snead, R. M. VanVleet, and C. T. Evans, all of Milwaukee and vicinity. Notably well done was the effort to make the dinner a true reflection of an old-time German festive affair in keeping with the best local custom, and those customs traditionally if not too accurately ascribed to Milwaukee. The German menu was more than most of those in attendance could decipher, but the result was voted a genuine success. Likewise the entertainment proved to be particularly well arranged, and was brought to a well conceived climax at the close of the dinner. The dinner entertainment features included the local and highly popular "Heidelberg Quartette," properly costumed and most popular when reflecting a German atmosphere; a "German street band"; two "sisters" in a Dutch wooden shoe dance; and subsequently in a song presentation Miss Kathleen Sauerwald, a contralto accompanied at the piano by her sister, whose beautiful presentations repeatedly "brought down the house" with round after round of enthusiastic applause. For the dancing subsequent to the meal, the "Electric Orchestra," electrical reproducing equipment functioning through a public address system set up for the occasion and operated under the engineering guidance of R. E. Deland and Sam Snead, admirably (and very economically) supplied selected dance numbers to supplement the efforts of "Heine's Band."

A registration exceeding expectations by 50 per cent was efficiently handled by J. U. Heuser and his committee: F. T. Coup, J. L. Defandorf, W. H. Fernholz, I. L. Illing, C. G. Matthews, and H. A. Bartlin. Mr. Heuser's committee was effectively assisted in registration work by a group of young women generously supplied by the Milwaukee Association of Commerce. The Pfister Hotel was exceptionally generous in making available without cost rooms and services for meeting purposes.

One of the features of the Milwaukee meeting was a policy of no registration fee either for members or students. The success of this policy, in spite of the heavy offering of inspection and entertainment activities, was made possible by the hard work of the finance committee under the direction of Fraser Jeffrey, of Milwaukee, and his committee: R. L. Dodd, P. B. Harwood, and H. L. Van Valkenburg, of Milwaukee; and K. A. Auty of Chicago, Ill. That the publicity efforts of R. R. Knoerr and his aid, J. H. Sobey, were effective was evidenced by the repeated attention given to the meeting by Milwaukee and other Wisconsin papers.

Executive Committee Memorializes Leaders

Two long-active leaders in the affairs of the American Institute of Electrical Engineers, recently deceased, were memorialized by the executive committee of the Institute's board of directors at its regular meeting held at national headquarters March 9, 1932. Resolutions adopted giving official recognition to the valued services of former National Secretary F. L. Hutchinson are recorded in full on p. 227 of this issue; those recognizing the services of the late Dr. Harold Babbitt Smith, past-president of the Institute, follow:

WHEREAS: Through the death of Professor Harold B. Smith the American Institute of Electrical Engineers has lost one of its most active and influential members, a noted leader who had rendered valuable services as a member of many committees, a director, a vice-president, and as president,

WHEREAS: His keen interest in District, Section, and Branch activities and his success in encouraging their development contributed much to the growth and influence of the Institute,

WHEREAS: His vigorous leadership in electrical engineering education and research, his ability to correlate developments in theory and practise, his deep interest in the progress of his students and former students, as well as his quiet, persistent enthusiasm for the development of the entire electrical engineering field won the high respect of many friends, be it, therefore,

RESOLVED: That the executive committee on behalf of the membership hereby expresses its sense of the great loss which the Institute and the entire engineering profession have sustained, and be it further

RESOLVED: That these resolutions be entered in the minutes and that a copy be transmitted to members of his family.

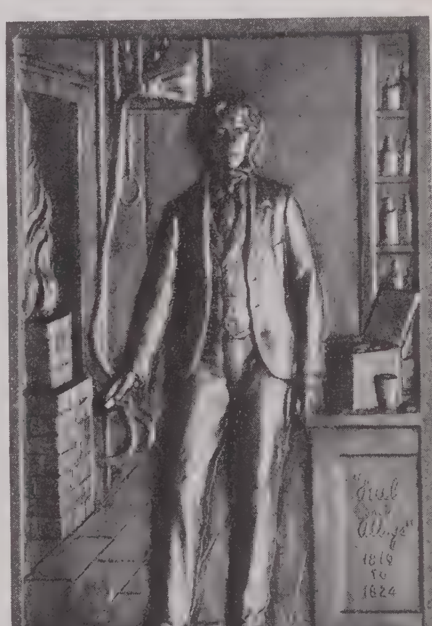
American Welding Society to Meet in April.—A tentative program has been announced for the annual meeting of the American Welding Society to be held in the Engineering Societies Building, 33 West 39th Street, New York, N. Y., April 27–29, 1932. Five technical sessions including 23 papers, covering a wide variety of subjects, have been scheduled. In addition there will be a business session and meetings of the board of directors, the structural steel welding committee, and the American Bureau of Welding. The eleventh annual dinner which will be arranged as a stag affair is scheduled for the evening of April 28.

Faraday Plaque Given to the Institute

Sir Robert A. Hadfield, London, England, has presented to the Institute a bronze plaque of Michael Faraday, having as a background the workshop in which Faraday performed his experiments on steels and alloys. On the right is shown a box, labeled by Faraday, and in which were found 79 of his specimens of steel and alloy steel, while on the left is shown the famous "blast" furnace used by Faraday. The plaque has been accepted by the board of directors of the Institute.

It measures 13 x $8^1/_2$ in., and is a replica of that prepared by F. J. Halnon, a sculpture of some note in London, and used as the basis for the frontispiece of a book "Faraday and His Metallurgical Researches" recently written by Sir Robert Hadfield. This book, having special reference to the development of alloy steel, has been prepared by a man who is himself not only a disciple of Faraday, but also a metallurgist through his numerous researches contributing much to the development of magnetic and other steels.

The story deals with the work of Michael Faraday during the period between 1819 and 1824 when he confined his investigations to the realm of metallurgy. This was his first research and led to others which he later made in chemistry and electricity. In addition to the historical matter in the book,



much technical information is included, so that a careful study may be found to be of practical importance. Considerable research and investigation were undertaken in preparing the text, and the author has combined these results with the historical data in a volume most pleasing and interesting to read. The book, 329 pages in length and carefully illustrated, is published by Chapman and Hall, Ltd., London, England.

Summarized Review of Some Winter Convention Discussions

PRINCIPAL discussions of winter convention papers are summarized herewith. The papers to which these discussions refer were abstracted in ELECTRICAL ENGINEERING for January 1932, p. 39–49 and February 1932, p. 130–2, excepting only the papers given more complete treatment in these same issues; additional articles based upon these papers are being presented in subsequent issues.

Only discussion submitted in writing in accordance with governing A.I.E.E. rules is summarized. Complete discussion together with all approved papers will be published in the TRANSACTIONS.

Protective Devices

A New High Speed Distance Relay

J. H. Neher (Philadelphia, Pa.) discussed this paper and pointed out that no assurance is offered that the relay will operate on a high-speed basis when three-phase flashovers of low arc impedance occur near the relay. He believed the problem could not be solved until there is developed a directional element which will give high-speed operation under this condition.

O. C. Traver (Philadelphia, Pa.) in his discussion of this subject remarked that the modified impedance relay described in the paper was a distinct step in advance over previous impedance relays. He agreed that, if it is to work selectively, the reactance relay must be provided with greater discriminating power than the impedance type. On the other hand he believed that the straight impedance type, and to a lesser extent the impedance-reactance relay, was apt to be too conservative and neglect its duty, so reactance would be the preferable function.

W. A. Hillebrand (Barberton, Ohio) inquired, in connection with the use of the series condenser as indicated in Fig. 6 of the paper, if there would be any inherent objection to using a bushing or other potential device instead of the series condenser to obtain the lead angle.

R. D. Evans (East Pittsburgh, Pa.) in his discussion summed up conditions which prevail on modern power systems. He explained that these conditions create a need for the modified impedance relay described in the paper. This device while still retaining its characteristic as an impedance relay minimizes the effects of fault resistance.

Oil Circuit Breakers

Philip Sporn (New York, N. Y.) reported that during the past year great improvement in breaker and system performance was obtained by the use of both the deion grid and oil blast explosion chamber breakers. Another point which he stressed was the inadequacy of the present standard duty cycle. In view of recent developments and tests, manufacturers were urged to offer users of oil circuit breakers a duty cycle which would be more consistent with actual power system operation.

J. Slepian (East Pittsburgh, Pa.) discussed "The Theory of Oil Blast Circuit Breakers" and disputed several of the principles. He explained the useful function of an arc by considering what would happen should it not form spontaneously when separating a pair of contacts in a power circuit. The hydromechanical principles also were analyzed as was some of the data; the discusser contended that some data given in the paper did not support the author's claims.

E. J. Poitras (Philadelphia, Pa.) answered several questions raised in discussion of this subject. He explained that the first group of tests was made where rates of rise of recovery voltage above 500 volts per microsec. were not available. They were not made with a view to completely filling in the graph and so no effort was made to obtain abnormally low oil velocities. When plotted in terms of recovery voltage rate and oil velocity, each parameter covering a reasonably wide range showed the excellent correlation of these parameters with success or failure to clear the circuit at the first current zero. He further explained that while it would have been desirable to make tests at all oil velocities and recovery rates and for all different generator voltages, such were not deemed advisable because, in circuit interruption, recovery voltage rate rather than nominal voltage is unquestionably predominant, and the making of many tests is expensive.

W. K. Rankin (Philadelphia, Pa.) in his remarks referred to the theory of deionization by turbulence as compared with the closing of the arc path at current zero by a fluid dielectric. He believes that the former theory bore some weight, even though in the case of an arc drawn to considerable length in a tank of oil other theories have been proposed. However, when considering a maximum of 1 in. contact separation, and recovery voltage rates of rise from 135 to 800 volts per microsec. across the contacts, tests have proved that the gaseous dielectric would not prevent breakdown; therefore he concludes that oil which does have sufficient dielectric strength is inserted between the contacts.

F. H. Stoppelman read a discussion on this subject prepared by C. L. Fortescue (East Pittsburgh, Pa.) which referred to early experimental work. The results indicated that something besides length was required to quench an arc. In fact, as shown in the papers by Messrs. Browne, Van Sickle, and Leeds, the requirement now is a turbulent gas stream across the path of the arc. He believed data on the oil blast principle would be explained just as well by the fact that the gas formation and its turbulency are functions of the velocity by which the oil is introduced into the ionized path between electrodes.

J. B. MacNeill (East Pittsburgh, Pa.) in his discussion of circuit breakers drew attention to the general improvement made in these interrupting devices and the reduction of the hazards which result from the use of oil in these devices. He believes the oil blast device operating on one end of the arc to be most effective for low voltages; however, for high voltages he questions its ability to produce effective results, and advocates the deion grid principle of interposing successive increments of arc rupturing ability as the arc is lengthened by the gases which have formed passing transversely across the full arc length.

T. E. Browne, Jr. (East Pittsburgh, Pa.) discussed this subject, in his conclusion submitting three reasons why it was impossible for him to agree with Mr. Prince's conclusions. One of these reasons was that as yet no detailed picture capable of withstanding critical analysis has been presented of the mechanics by which the oil film may be formed.

Extinction of A-C. Arcs

R. C. Van Sickle discussed this subject and pointed out certain differences between the functioning of the experimental structure described by Mr. Browne and the deion grids, which differences should be realized when comparing results as they might explain why the recovery voltage gradients of deion grids are higher.

J. J. Torok (East Pittsburgh, Pa.) discussed this subject and described an experiment on extinguishing arcs in fiber tubes wherein droplets in the tube materially increased the surface on which ions could be collected. He found that the author's treatment of the expulsion fuse substantiated the theory of the turbulent gases.

W. A. Hillebrand (Barberton, Ohio) discussed this subject also and briefly described the Poulsen radio arc transmitter. He believes that the curves presented by Mr. Browne confirm earlier experience with this transmitter. He also offered as a possible contributing cause for the difference between the curves of Fig. 6 for oxygen and nitrogen, the fact that free electrons can exist in an atmosphere of nitrogen but not in an atmosphere of oxygen.

Instruments and Measurements

A Power Factor Bridge of High Sensitivity

Perry A. Borden (Waterbury, Conn.) discussed this subject and described a method of balancing out induced voltages in the galvanometer coil by the use of a neutral inductance in the field circuit; this would appear to remove one of the objectionable features of the electrodynamic galvanometer.

J. C. Balsbaugh (Cambridge A, Mass.) discussed this subject and told of a modified Schering bridge using an amplifier in the detector circuit offering a precision in power factor measurement of 10^{-6}, this modified form having been constructed at the Massachusetts Institute of Technology. When all the factors affecting the power factor precision of the bridge have been fully investigated, it is planned to make formal publication of this research. In conclusion, the discusser pointed out that there were no calculations or tests giving the sensitivity or

precision of the bridge described in the paper.

Leo J. Berberich (Paulsboro, N. J.) discussed the high accuracy of power factor measurements possible when using a bridge of the type described in the paper. He gave data which showed the excellent agreement found between the computed power factor of the standard and the power factor as measured by the bridges of the type described by Doctor Kouwenhoven. It evidenced also close agreement between the two bridges used at the Johns Hopkins University.

S. K. Waldorf (Baltimore, Md.) analyzed several cases mentioned in this paper, commenting upon the net effect of a reduction of specimen size, high humidity conditions, and double shielding on the transformer used in the galvanometer circuit. He also warned those who have occasion to build small high voltage air capacitors against the use of small plate dimensions, and a spacing of not less than five millimeters was suggested.

One of the points considered by R. P. Siskind (Cambridge, Mass.) in his discussion of this paper was the possible effect upon the accuracy of the bridge from the presence of harmonics. He explained that when a potential sufficiently high was applied to the test specimen it would cause ionization producing third and other harmonics. It was believed that these might cause some small error to exist in the bridge.

Instrument Springs

A. B. Smith (Chicago, Ill.) discussed the use of the grid glow micrometer mentioned in the paper. He told of having previously compared the use for detection purposes of a 2-watt, 110-volt neon lamp with a radio headset. The comparison revealed advantages in the use of the receiver, such as sensitivity when the resistance was greater than 59 megohms. Also with the use of a receiver for detection, the eye is left free for other observations.

J. R. Townsend (New York) discussed the means of stabilizing instrument springs and referred to the work of Sayre, Dalby, Scott, and Abbott. He believes the method of heating above the service temperature as suggested by Messrs. Carson and MacGahan, to be a good one.

An Automatic Oscillograph

Wm. G. Walker (Philadelphia, Pa.) told of experience at Plymouth Meeting Substation with a development model and later a commercial model of the oscillograph described in the paper. Several suggestions advanced by the men maintaining the development model were incorporated in the commercial model. Out of 63 operations recorded during an interval of 160 days, no records were lost through failure of the instrument to function.

The Photoelectric Recorder

P. E. Quiss (Lynn, Mass.) discussed this subject and emphasized the sensitivity and quick starting features of this apparatus which enable it to record values heretofore measured only by the use of indicating instruments.

C. W. Mayott (Hartford, Conn.) explained that the photoelectric recorder had been installed in the load supervising office at Hartford. It has been in service for

The Engineer President

WITH SIMPLE CEREMONY this de Laszlo painting of Herbert Hoover—Honorary Member of the civil, mining, mechanical, and electrical engineering societies and past-president of the American Institute of Mining and Metallurgical Engineers—was unveiled February 15, 1932, before a meeting of the United Engineering Trustees, Inc., held in the Engineering Societies Building at 25–33 West 39th Street, New York, N. Y. To this meeting were invited the presidents, vice-presidents, secretaries, and boards of directors of the four national engineering societies, and a few other especially prominent engineers and organization representatives. As chairman of the Hoover Medal Board of Award, representing the four engineering societies, Dr. Gano Dunn, past-president of the Institute, delivered the portrait to H. A. Kidder, Fellow of the Institute and president of the United Engineering Trustees, the organization which will be the official custodian of the portrait.

President Hoover kindly sat for the painting during Christmas week, 1931, in response to a request made jointly by the four national engineering societies. The portrait was arranged for at that time in order to take advantage of the presence in this country of the internationally known artist, Philip A. de Laszlo of London, England. The portrait of President Hoover, mounted in a valuable frame contributed by the artist, now is the joint property of the four engineering societies and is to be hung prominently on the east wall of the reading room of the Engineering Societies Library "where it can be seen by engineers and the public alike, and where it may constantly stir to pride and emulation the members of the engineering profession."

approximately a year and a half. During this time the only replacement required was the light source bulb. Frequency records were obtained in such detail as to be beyond the requirements of any present operating demands.

H. A. Rolnick (Philadelphia, Pa.) inquired regarding the smallest angular motion of the indicating element to which the recorder would respond, and whether or not it was dependent on the electrical circuit, the optical system, or both.

Distribution Circuit Lightning Protection

Harold C. Dean (New York, N. Y.) expressed belief that the most important contribution made to the industry by the papers in this symposium was the proof offered that lightning arrester ground leads should be connected to the secondary neutral where the latter is adequately grounded; he advocated also the grounding of transformer cases to the secondary neutral. It was explained that those in the New York Edison Company have the philosophy that a known hazard is to be preferred to an unknown hazard, and they have adopted as a standard the grounding of all transformer cases.

A. H. Schirmer (New York, N. Y.) explained that the results obtained from Bell system tests indicated that for transformer protection an arrester should be placed between the primary and secondary. The arrester should have a current limiting element so designed that the voltage across the transformer windings would be held to a value slightly below the impulse strength of the transformer. This would hold to the lowest practical value the lightning voltage on the secondary caused by a surge on the primary, and no power voltages of considerable magnitude would appear between the secondary circuit and ground.

F. W. Peek (Pittsfield, Mass.) suggested that with an object to devising lightning tests the proper technical committees of the Institute should review present methods of testing. These tests were suggested as a supplement to the present tests and not to supersede them. This suggestion for consideration was made after years of experience with lightning tests on transformers in an effort to devise lightning proof transformers and also for making lightning tests on commercial transformers. These facts were mentioned to show that lightning tests are entirely practicable.

A. E. Silver (New York, N. Y.) called attention to the change in trend toward the objective of lightning protection. He explained that in the past, attention to the subject of lightning on distribution circuits seemed to have centered on the distribution transformer and what could be done to protect it rather than upon lightning effects on service. He commended the authors of the paper on the Philadelphia Electric system for moving the main objective of their studies from the distribution transformer to its effects upon service.

C. L. Fortescue (East Pittsburgh, Pa.) analyzed the proposed connection of the lightning arrester ground lead to the secondary neutral as advocated in the papers. He believes that the proposed connection assured much better protection to the transformer than the old connection, without any increase in hazard to the customer. As compared with unprotected transformers, he believes the connection gives much better protection to the customer because it prevents high voltage from entering into customers' circuits. Also the hazard of fire or personal injury is much greater from high voltage power current than it would be from any surge likely to pass through into customers' circuits.

A. S. Brookes (Newark, N. J.) discussed several details in the paper by Messrs. Harding and Sprague. He believes the analysis might have been made much more valuable by a more detailed consideration of the circuit distances involved, and if more data on the surge current and the circuit details were given. He felt that the interconnection of the primary arrester ground and the secondary neutral had more merits than the results given in the paper indicate.

J. K. Hodnette (Sharon, Pa.) discussed this subject from the standpoint of distribution transformer design. He described a self-contained, self-protecting transformer with gaps inserted between the high-voltage and low-voltage leads, and the ground, to enable the transformer to withstand many surges without injury to the insulation. This surge-proof transformer has withstood tests approximating service conditions as nearly as possible, with surges of various magnitudes up to 1,500,000 volts impressed upon the excited supply lines. In every case the transformer was protected and normal voltage was restored without causing so much as a flicker in lamps supplied from secondary leads of the transformer.

H. V. Putman (Sharon, Pa.) pointed out limitations of the proposed interconnection which he believed ought to be given careful consideration. He explained why he believed the straight interconnection not well adapted to installations having a low voltage neutral ground connection of high resistance, nor to installations without grounds on the service lines; nor yet to installations with grounded transformer tanks or to three phase installations.

M. G. Lloyd (Washington, D. C.) summed up results and conclusions of the several papers on lightning protection. He explained that the committee on protection against lightning of the National Fire Protection Association for some time has had under consideration the advisability of using lightning arresters on overhead secondary circuits where they enter buildings. This would seem necessary only in rural districts and where wires enter the building as separate open wires. Since it would be necessary to interrupt follow current at only 120 volts, an arrester of cheap construction would suffice.

J. J. Torok (East Pittsburgh, Pa.) discussed and carefully analyzed benefits to be obtained from the standpoint of personal hazard to the customer in the proposed interconnection of the lightning arrester ground lead and the neutral of the secondary. He explained that without the interconnection a power arc established across the transformer terminals would raise the secondary leads to primary potential. This condition would last as long as the arc was maintained, probably for several seconds. With the interconnection the action of the lightning arrester would come in at a voltage lower than that at which flashover of the transformer bushings would occur. Thus the arrester would prevent 60-cycle power follow or would limit it at most to a half-cycle duration. The power follow is more dangerous to life than the impulse voltages which, although of much higher values, are of short duration.

Edward Beck (East Pittsburgh, Pa.) described tests performed on a circuit set up in the laboratory to simulate an energized 2,300-volt circuit feeding a 110/220-volt house circuit with various household appliances attached. The transformer was protected with a 3,000-volt auto-valve arrester with the proposed interconnection employed. Surges were impressed on the primary of magnitudes sufficient to discharge 800, 1,600, and 3,000 amperes through the primary arresters, and cathode ray oscillograms were made of voltages occurring on the secondary system. The ground resistance was varied from zero to 57 ohms. The results revealed that the voltages to ground of the phase wires and the neutral wire were very nearly alike except for the first instant. Well over 1,000 surges were impressed and only three interruptions to the customers' service occurred. These consisted of blown fuses only. From the results obtained it was concluded that the interconnection did not impair conditions in the secondary system.

K. B. McEachron (Pittsfield, Mass.) discussed the proposed interconnection and described a modified form of conventional lightning arrester for installation within the space available inside the transformer tank. The arrester operation is in no way different than when applied externally, having the same factors of safety and the same reliability. This construction would have the advantages of reducing both installation costs and congestion on poles. Reasons, the result of experience, were given showing why gaps were unsuitable.

General Circuit Theory

R. D. Evans (East Pittsburgh, Pa.) briefly reviewed some of the developments which have taken place in general circuit theory during the past 20 years. He told of any early problem in power system networks which was in connection with the supply systems for a-c. railways. This he explained was followed by a very important step in network theory; namely, the introduction of the method of symmetrical components by Doctor Fortescue, to make possible the solution of unbalanced power system networks. He further explained that recently the stability problem has made it necessary to develop new forms of circuit constants in order to facilitate the solution of general networks, taking into account not only distributed constants but their combination with lump constants. In conclusion, he pointed out that the most striking development within the last few years was the introduction of the a-c. calculating board. This has made possible the solution of many problems in a more complete manner and in less time than heretofore required.

Equivalent Circuits

J. W. Butler (Schenectady, N. Y.) illustrated with examples the usefulness of the

(*Continued on p. 276*)

Cleveland Cordially Invites You

To the Annual Summer Convention, June 20-24, 1932

The committees are working hard to assure you a profitable and entertaining visit. No registration fee.

Cleveland Museum of Art, inspection of which is included in the ladies' entertainment program for Monday, June 20, 1932

Inspection of Severance Hall, the new home of the Cleveland Symphony Orchestra, with the most modern lighting in the country, is included in Friday's program

Preliminary plans include a boat trip on Lake Erie Tuesday evening

Garfield's Tomb, one of the many points of interest in Cleveland

The Cleveland Union Terminal group on Public Square, including Cleveland Hotel (at the extreme right) which is to be the convention headquarters

(Winter discussion continued from p. 274)
method which Mr. Starr had developed in part III of his paper, for setting up several simplified equivalent circuits. One example illustrated the simplicity of setting up an equivalent single line circuit to represent a four winding transformer.

Edith Clarke (Schenectady, N. Y.) explained that the paper on this subject presented the general circuit equations for networks in systematic and concise form, with methods for measuring and calculating the characteristic coefficients. She felt that Mr. Starr had made a valuable contribution to their solution. She believed also that one of the simplifications which will be found of advantage, where an a-c. calculating table is not available or when greater accuracy is required than can be secured by its use, is that of placing the self-impedance at the terminals and not in the mesh of the equivalent circuits.

R. G. Lorraine (Schenectady, N. Y.) discussed this subject and believes the paper, with its presentation of the general principles upon which the development of specific equivalent circuits depends, to be a welcome addition to the literature on equivalent circuits. One of the points which he emphasized was that even though the author's equivalent circuits contain pure reactance branches means are available to represent them adequately on the a-c. calculating table.

W. A. Lewis (East Pittsburgh, Pa.) found several of the equivalent circuits presented by the author to be both new and interesting. He believes a slight error in statement appeared on page 5 and again in the footnote on page 9, where it was stated that the mutual impedance between lines is purely reactive. It was explained that the mutual impedance is due not only to inductive coupling but also to the common use by all circuits of the earth and ground wires, if present. This resistance often may be as large in proportion to the mutual impedance as the combined resistances of earth circuit and conductor is to the zero phase sequence self-impedance. Therefore it seldom can be neglected unless the accuracy required permits neglecting all resistances.

George W. Hampe (Chicago, Ill.) in his discussion of this subject referred to previous work and the principles stated in 1911 by Mr. G. A. Campbell. He explained that the complete or lattice mesh, of which Fig. 1(d) and Fig. 3(b) of the paper are examples, could be handled more readily if admittances instead of impedances were used to express its links. A simple process for finding the branches of the complete mesh equivalent to the general concealed network was given by Mr. Campbell. The discusser gave an example of its derivation without the use of determinants.

Transient Oscillations of Mutually Coupled Circuits

H. L. Rorden (Pittsfield, Mass.) discussed this subject and illustrated several points of interest with specific calculations based on Mr. Bewley's derivations. A table of calculated transients was given listing the essential terms for three space harmonics as calculated for the given constants, and conclusions drawn from these calculations were enumerated. An analogy also was given by comparing the general distributed circuit with the lumped constant circuit which exhibited similar characteristics.

Drives for Power Station Auxiliaries

A. H. Kehoe (New York, N. Y.) told of experiences in the New York Edison system with both steam and electric drives for power station auxiliaries; continuity of station output has been obtained with either steam or electric auxiliary drive. This has been accomplished by supplying steam from headers which are provided with sectionalizing valves and fed from two or more sources, and each essential auxiliary motor circuit has its supply available from several sources. This system has found some saving in installed first cost of auxiliaries with electric drive instead of steam, especially where the simpler types of motors are adaptable.

I. E. Moultrop (Boston, Mass.) believed the papers presented on this problem were valuable and timely in bringing to the attention of the industry the need for more suitable and more economical drives. He predicted that auxiliary power requirements of the stations built in the future probably will be considerably in excess of those past or present. For high pressure boiler feed pumps he favored the use of turbine drive because it permits the best pump design, and the usual horsepower requirements permit a highly economical design. He called attention to the lack of satisfactory variable-speed a-c. motors, and many other interesting points were brought out in his discussion of this subject.

Francis Hodgkinson (Lester, Pa.) emphasized the importance of reliability of the drives for the essential power station auxiliaries. He discussed the trend in modern power plant design and in particular, stage bleeding for preheating, which no longer makes the exhaust heat from steam auxiliaries essential. His considerations in addition to the statements in the papers led generally to a preference for the electric drive for all essential auxiliaries except boiler feed pumps and fans.

H. M. Cushing (Buffalo, N. Y.) believed the trend of the development was clearly depicted in the three papers by Messrs. Hollister, Dryer, and Smith. However, he believed Mr. Dryer in handling the subject of steam driven auxiliaries had made a very favorable case for the electric drive. He was in agreement with all conclusions in this paper except Nos. 1, 5, and 8. It was explained that the Huntley Station started with a preponderance of steam driven auxiliaries. However, its engineers and operating men are now so convinced of the superiority of electric drive that in the new 60-cycle steam plant, known as Huntley Station No. 2, it was used exclusively for driving the auxiliaries. He explained further that the general use of electric drive had been delayed by a number of causes and pointed out many important features of the electrical installation for electric drives.

F. C. Hanker (East Pittsburgh, Pa.) reviewed the requirement for electric auxiliary drives and carefully analyzed the characteristics of the available types of apparatus. He felt that a great deal of the criticism of electric drive was due undoubtedly to the effort to apply motors and control developed for industrial uses to the more rigorous duties imposed by central station conditions. It was believed that the trend toward the unit system of operation should permit simplification of both the power supply and the auxiliary drive. Complications should be avoided in the sources of supply; this would simplify the control for the auxiliaries as well as minimize the duplication of auxiliaries, as is frequently done in practise.

Robert Baker (New York, N. Y.) discussed the financial side of this question. He believed that comparisons between steam and electric drives for auxiliaries

Floodlighting for Hockey Rinks at Lake Placid

THE TWO hockey rinks and the adjacent ice skating speed tracks for the Olympic stadium at Lake Placid, N. Y., are floodlighted by the well diffused rays of 29 General Electric Company floodlights. Several of the hockey matches and races of the Olympic games, February 4–13, 1932, thus were successfully conducted at night. A total of 43 kw. is required to illuminate the 245 x 628 ft. of ice surface.

should be made on the basis of between 30 and 40 per cent capacity factor instead of maximum load conditions, as described in the paper on electric drives. A comparison on this basis would represent more nearly the actual operating conditions and would probably show a reduced saving. He pointed out that no figures were given as to the cost of the steam driven equipment required for a station using steam driven auxiliaries and that comparisons could be made up only on the basis of fuel cost. It was explained that comparisons of this nature gave only half the picture as an analysis of the over-all operating costs of the average plant shows that the cost of fixed charges is approximately equal to the fuel cost.

Philip Sporn (New York, N. Y.) believes the aim in auxiliary layouts for future power plants should be toward further simplification of the power supply and control equipment. He believes the merits of systems were now fairly well recognized so that further standardization and simplification could take place. The need for a simple, sturdy, variable speed a-c. drive, improved insulation, and consideration of the use of higher voltage motors, were some other interesting points brought out in this discussion.

S. M. Dean (Detroit, Mich.) believes that the papers give a good summary of the two situations so far as the auxiliaries themselves were concerned. However, he would like to have seen somewhat more complete cost data. It was also pointed out that the possibilities of d-c. drives should not be overlooked. When account is taken of the extent to which the station rating is reduced (some 5 per cent) the smoothness and ease of operation, the absence of serious short-circuit problems, etc., it does not compare unfavorably with other methods.

F. M. Stoddard (Cincinnati, Ohio) briefly described auxiliary installations at the Columbia power station. Power for the essential auxiliaries is supplied from shaft generators connected to each main turbine unit. The non-essential auxiliaries are supplied from transformers connected to the main bus, and in six years of operation there has been no trouble with the auxiliary system from loss of auxiliary power or fluctuation of bus voltage caused by external faults.

F. H. Hollister (Chicago, Ill.) in his discussion on this subject showed data on several desirable features of the Rossman drive which has been in successful operation for the past year, driving fans at the Powerton station.

Symposium on Stability

Standard Decrement Curves

R. G. Lorraine (Schenectady, N. Y.) discussed this subject and analyzed the development and use of several of the curves presented in the paper. An example illustrating their use was given and further inspection of them showed that more confidence could be placed in the use of these curves than one would suppose from an inspection of the assumptions made in their derivation.

Decrement Curves for Specific Systems

H. B. Dwight (Cambridge, Mass.) discussed this paper with particular reference to a method for calculating sustained short-circuit currents using Potier reactance. He explained that for this calculation the value of armature ampere-turns at rated current is also required, and this may be obtained from the Potier triangle. A certain amount of zero power-factor armature current may be assumed and the excitation calculated using Potier reactance and armature ampere-turns. It was further explained that since the excitation usually is known, the calculation must be repeated with adjusted values of armature current until the resulting excitation has the correct value. This process seems necessary, and does not make the calculation unduly long.

Proposed Definitions of Power System Terms

V. J. Cissna (New York, N. Y.) explained the preference for the convention of leading reactive power as positive, particularly on account of the power-circle diagram. This he illustrated with a figure. It was believed that in considering leading reactive power as negative the convention of the power-circle diagram had been troublesome to many engineers in that the conventional rotation of voltage vectors had been violated.

C. L. Dawes (Cambridge, Mass.) commented on the committee's definition of lagging reactive power in terms of the current delivered by an over-excited synchronous generator. He believes this to be an indirect and unnecessary method of defining reactive power and also that it is confusing to those who do not have immediately in mind the excitation characteristics of synchronous apparatus. Such reactive volt amperes he believes could have been much more explicity defined as the reactive volt amperes taken by an inductive reactance, and this would be easily understood by everyone familiar with alternating currents.

C. F. Wagner (East Pittsburgh, Pa.) also discussed this question as to whether or not inductive reactive power should be plotted as a positive or as a negative quantity in power circle diagrams. He gave a list of references to publications in which inductive reactive power is considered positive and also a list in which it is considered negative. These references dated over a period from 1910 to 1929, twenty-three authors considering inductive reactive power as positive while sixteen considered it as negative. In addition, authors such as Doctor Kennelly, Professor Jackson, and Doctor Fortescue, also preferred the use of the positive value. Therefore, the discusser believes that the inductive reactive power as a positive quantity should be adopted as the convention.

Edith Clarke (Schenectady, N. Y.) explained that she was in agreement with the proposal to consider leading reactive power positive and lagging reactive power negative. It was explained why voltage is chosen as the reference vector in dealing with network systems; the currents in the branches of the network then give a good indication of both active and reactive power flow. This correspondence of power and current was believed to be of sufficient importance to justify the proposed convention for active and reactive power.

A. E. Kennelly (Cambridge, Mass.) told of the work done by the International Electrotechnical Commission and analyzed considerations of the question as to whether reactive power should be represented by $P + jQ$ or $P - jQ$ vector voltamperes. He believes the subject committee here should transmit a recommendation to the A.I.E.E. standards committee as to the choice of vector direction so that the standards committee may be able to take early appropriate action with a view to renewing international proposals. If the reasons given for the final choice are cogent, he believes they would be likely to meet with indorsement from our engineering fraternities in other parts of the world.

L. A. Kilgore (East Pittsburgh, Pa.) discussed section 4 of this report covering the definition of synchronous machine constants with particular reference to the effects of saturation. He believes the report does not offer any simple method of dealing with the effects of saturation but leaves its degree indefinite. This he thinks might be confusing when using the constants in practical calculations for it appears we must have not only a large number of constants but different values for various conditions. It also will be necessary to state the degree of saturation every time a value of the constant is specified. He recommends from the conclusions of previous work, a definite and relatively simple means of dealing with saturation.

S. L. Henderson (East Pittsburgh, Pa.) believes the report to be a valuable piece of work. He suggests that a statement would be helpful in covering the particular machine constants to be used most often in the ordinary study of system performance. For example, values of transient, substransient synchronous, and negative and zero sequence reactances for the direct axis, together with the short-circuit ratio and the short-circuit time constant, are sufficient for the usual practical case.

Generalized Stability Solution for Metropolitan Type Systems

R. D. Evans (East Pittsburgh, Pa.) called attention to the value of the generalized methods given in this paper. He explained that the general stability curves given in this paper may be used in a manner similar to that of the paper "Standard Decrement Curves" presented earlier in the session. It was predicted that the use of these curves together with previous curves developed for long distance straightaway transmission will lead to the development of similar methods for the remaining types of systems so that eventually shortcut methods will be available for all types of systems.

Another discussion by S. B. Crary (Schenectady, N. Y.) brought out that any generalization or simplification of a problem which comprises as many factors as a transient stability study, must require numerous assumptions and these limit the field of application. Therefore he believed that care must be used in applying the curves of Figs. 1 and 2 to systems that do not conform to the assumptions set forth.

S. H. Wright (Buffalo, N. Y.) explained that when applying the curves presented in the paper cases may frequently arise where conditions of the system being studied are

met by the conditions assumed in preparing the curves except in one respect, making it desirable to consider the inertia constant as an additional "index factor." This was illustrated by an example.

Electrical Stability of Conowingo Hydroelectric Station

R. M. Spurck (Philadelphia, Pa.) discussed the last paper to be presented in this session. He believed the authors presented an excellent and complete paper on the analysis and solution of stability problems which occurred in connection with the operation of this station, both before and after the application of high-speed clearing equipment to the system. It was brought out that the correction of stability problems by high-speed circuit clearing also brings with it many other benefits, a few of which are reduced area of disturbance on the system during faults, reduction in voltage dips, and apparatus that requires less maintenance.

Research

Radio Interference From Insulator Corona

J. W. Upp, Jr. (Baltimore, Md.), discussed this subject and he believes that over a period of years, insulator manufacturers interested in radio interference investigations have found modern insulators to be minor offenders. Insulators, he thinks, are further along the path of development of radio interference relief than most of the other factors involved in the manufacture, transmission, and consumption of electrical energy.

W. A. Hillebrand (Barberton, Ohio) inquired if the author of this paper considered his set-up suitable for a standardized test set, if he had any changes to recommend, and if, in his opinion, it had been described with sufficient accuracy in his papers to permit of its being accurately reproduced.

S. K. Waldorf (Baltimore, Md.) discussed several means for corona detection, one of which consisted of employing an audible corona detector having one or two stages of audio frequency amplification designed to accentuate frequencies greater than approximately 500 or 1,000 cycles per sec., and having a radio headset or loud speaker in the output. With this type of detector, even the presence of a small amount of corona is accompanied by a loud buzzing sound in the telephone or loud speaker. He also explained that it may be desirable in some cases to connect the input resistance of the corona detector in the grounding circuit of the insulator suspension or pin.

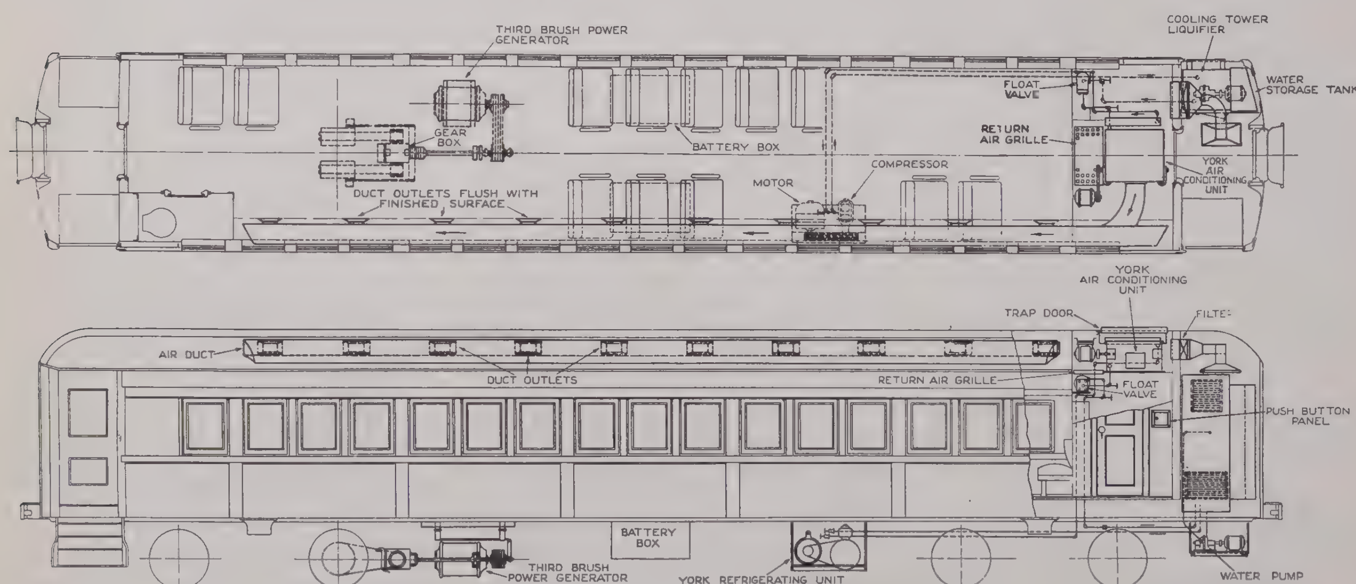
J. B. Whitehead (Baltimore, Md.) discussed the experimental method used in the paper with reference to balancing out the charging current of the high voltage circuit, the adjustment being made before corona forms. He explained that it is well known, however, that the presence of corona, owing to space charge formation, introduces important changes in the value of the geometric capacitance. It was believed that this fact might explain some of the irregularities in the records and have a bearing on the differences observed as between the negative and positive half-cycles.

Another discussion of this subject by A. C. Seletzky (Cleveland, Ohio) suggested that in view of the varying results obtained, a quantitative method of detecting the initial presence of corona should be used, as it would give more consistent results. Such a method he believes would be able to detect corona in parts of the insulator which are difficult, if not impossible, to observe accurately by visual means, even under the most favorable conditions and a darkened room.

Predetermination of A-C. Behavior of Dielectrics

H. H. Race (Schenectady, N. Y.) discussed this subject and it is his belief that the paper presents some very interesting data but it does not suggest a physical explanation of the results. He was particularly interested in Fig. 5, because the variations of capacitance and loss with frequency are similar to corresponding curves calculated using a very definite physical picture; namely, Debye's theory of polar molecules. An analysis and comparison of the two theories were made which led to several more general and interesting conclusions.

Baltimore & Ohio to Equip More Cars for Air-Conditioning



An initial order for new and improved equipment for 78 passenger cars has been placed [with the York Ice Machinery Corporation of York, Pa.] by the Baltimore & Ohio Railroad, pioneer in train air-conditioning. The new equipment, like that employed in the initial installation, is self-contained in each car to permit flexibility of operation. Power for driving the equipment is obtained from a newly developed three-brush generator, axle driven through a special gear and pulley arrangement, and a new high-capacity storage battery. Refrigeration is carried out in a closed cycle. The refrigerating unit consists of a compressor, specially designed for use with Freon gas (dichloro-difluoro-methane) and driven by an electric motor with both high and low pressure cut-outs and gages. The new gas employed is a colorless, odorless, non-corrosive, non-combustible, and non-inflammable refrigerant which may be used in equipment passing through tunnels without any serious hazard to health. The new equipment is said to have 50 per cent increased capacity, but to require less space than that used by the B & O in their original installation. Either an air-cooled or cooling-tower liquifier may be used, depending upon operating conditions; identical results are expected with either type. The accompanying illustration shows a typical passenger car installation, in which may be noted the arrangement of equipment and air passages. The entire system is controlled from a push-button station near one end of the car.

Another discussion by F. M. Clark (Pittsfield, Mass.) told of determining the relative a-c. characteristics of 5-kva. oil-filled capacitors by means of the so-called d-c. leakage. This appears to be of greater value than insulation resistance measurements, but the work was not carried sufficiently far to predict successfully the power factor from the leakage results obtained; however, it was believed that this could be done.

W. A. Del Mar (Yonkers, N. Y.) also discussed this subject and brought out the fact that the practical control of power factor of impregnated paper now lies with the paper tests, where formerly it was essentially a matter of oil resistivity. This change occurred when manufacturers changed their paper from manila to wood pulp, and oil from petrolatum to cylinder oil. He believes that the practical problem has long since been solved, but it would be interesting to have the authors explain these facts in the light of their admirably developed theories.

Breakdown of Glass
With Alternating Potentials

J. B. Whitehead (Baltimore, Md.) discussed this paper and found it difficult to accept the suggestion of Moon and Norcross, and now of these authors, that the intermediate stage of breakdown should follow a definite law.

W. A. Del Mar (Yonkers, N. Y.) discussed the authors' contention that three distinct regions of dielectric failure, instead of two, exist with alternating currents. He believes that the authors in justice to their thesis should give Fig. 4 with the experimental points plotted.

W. A. Hillebrand (Barberton, Ohio) discussed the nature of glass, the material used in these tests. He explained that glass is a physical solution, an electrolyte, the constituents of which are ionized, and that it has the high negative temperature coefficient of resistance characteristic of electrolytes. Furthermore, some of its physical properties are indefinite. Therefore, the discusser did not believe it was impossible that there should be a region of dielectric breakdown intermediately between the disruptive and thermal regions partaking of the nature of both and representing a transitional stage.

Another discusser, F. M. Clark (Pittsfield, Mass.) also drew attention to the nature of the material used. He believes that the conclusions drawn by the authors, even if accepted, should be limited carefully to glass of the type under discussion which also should be more clearly described than it was in the paper.

Magnet Steels

This subject was discussed by W. A. Codd (Rochester, N. Y.) who believes that the paper checks experimentally Evershed's criterion of magnetic quality for magnet steels and apparently offered a considerably simplified design method in the nomogram presented. The discusser also inquired in detail about many points in this paper.

Editor's Note: The remainder of these summaries of winter convention discussions is scheduled for inclusion in the May 1932 issue of Electrical Engineering.

Executive Committee of Institute Meets

A meeting of the executive committee of the American Institute of Electrical Engineers was held at Institute headquarters, New York, N. Y., on Wednesday, March 9, 1932, in place of the regular March meeting of the board of directors.

Present were: C. E. Skinner, *chairman*, and H. P. Charlesworth, J. Allen Johnson, W. S. Lee, F. W. Peek, Jr., W. I. Slichter, and C. E. Stephens, of the committee, and Assistant National Secretary H. H. Henline.

Resolutions were adopted in memory of the late National Secretary F. L. Hutchinson and Past-President Harold B. Smith, as published elsewhere in this issue.

Resolutions were adopted, authorizing and empowering H. H. Henline, assistant national secretary, to perform all of the duties of the office of national secretary until further order of the executive committee or the board of directors.

Approval was given to actions taken by the board of examiners at its meeting of March 2, 1932; and upon the recommendation of the board of examiners the following actions were taken upon pending applications: one applicant was elected to the grade of Fellow and two were transferred to the grade of Fellow; two applicants elected and 21 transferred to the grade of Member; 218 Associates elected; 99 Students enrolled.

The approval by the finance committee for payment of monthly bills amounting to $28,519.97 for January and $25,729.56 for February was ratified.

The assistant national secretary reported that upon being advised of the action of the board of directors in January, calling for a reduction in the expenses of the meetings for the remainder of the year 1932, the executive committee of the Southern District (No. 4) had voted to cancel the District meeting scheduled to be held in Memphis, Tenn., in November, 1932, with the idea that a meeting will be held the latter part of 1934 instead.

Appointment by the president of the following committee of tellers to canvass and report upon the ballots cast in the 1932 election of Institute officers, was confirmed: J. T. Wells, *chairman*, L. B. Bogan, H. B. Ely, C. S. Purnell, G. J. Read, R. H. Twiss, and Ernst Volckmann.

The resignation of J. C. Parker as a representative of the Institute on the standards council of the American Standards Association was presented, and the president was authorized to appoint a representative for the unexpired term of Mr. Parker, ending December 31, 1932.

Col. W. B. Jackson was appointed a representative of the Institute on the Commission of Washington Award, for the 2-year term beginning June 1, 1932, to succeed Prof. C. F. Scott, whose term expires at that time. Appreciation of the services rendered by Professor Scott in this capacity over a long period of years, was expressed.

The president was empowered to nominate for appointment by the president of the National Academy of Sciences, a representative of the Institute on the division of engineering and industrial research of the National Research Council, for the 3-year term beginning July 1, 1932, to succeed F. W. Peek, Jr., whose term expires at that time and who is ineligible for immediate reappointment.

Upon recommendation of the committee on education, it was voted to endorse the activity of the Society for the Promotion of Engineering Education in its summer schools for engineering teachers.

An invitation from the National Academy of Sciences to be represented by a delegate at the celebration of the one hundredth anniversary of the electrical discoveries of Joseph Henry, on the evening of April 25, 1932, in Washington, D. C., was accepted, and the president was authorized to appoint a delegate.

It was also voted to accept the invitation to send a representative to the celebration, on April 11, 1932, of the opening of the new patent office in Washington.

Other matters were discussed, reference to which may be found in this and future issues of Electrical Engineering.

Doctor Langmuir Receives Science Award.—The annual award of $10,000 offered by *Popular Science Monthly*, this year went to Dr. Irving Langmuir, physicist, chemist, and associate director of the research laboratories of the General Electric Company. The following institute members were among the committee of eminent engineers and scientists which chose Dr. Langmuir: Dr. F. B. Jewett (A'03, F'12) vice-president of the American Telephone and Telegraph Company, *chairman;* Dr. C. F. Kettering (A'04, F'14) president and general director of the General Motors research laboratories; Dr. S. M. Kintner (A'02, M'03) vice-president of the Westinghouse Electric and Manufacturing Company; Dr. R. A. Millikan (M'22) chairman of the executive council, California Institute of Technology; Philander Norton (A'11) assistant to the president, Bell Telephone Laboratories; and Dr. Willis R. Whitney (A'01) vice-president and director of research of the General Electric Company.

A.A.A.S. and Associated Societies to Meet at Syracuse.—Following the custom established last year of holding annually a summer meeting of truly national character, the American Association for the Advancement of Science, together with associated societies, will hold their second annual summer meeting in Syracuse, N. Y., June 20–25, 1932. Syracuse University will act as host for the meeting. Dean H. P. Baker of the College of Forestry has been appointed chairman of the steering committee and has organized the various committees which are to function in making the stay of the 2,000 scientists, who it is expected will attend the meetings, a pleasant one. The facilities at Syracuse University have been found suitable as a meeting place for such a large group. In addition to the hotels, University accommodations will be available for housing the visitors during the week of the convention. Visiting scientists will be able to make excursions to any points of interest in the vicinity, and guides will be furnished for the various trips.

Post-College Education Popular With Chicago Engineers

FOR NEARLY three years the educational committee of the Chicago Section of the Institute has been actively promoting the post-college education of engineers in that district. Prof. Edward Bennett, chairman of the Institute's committee on education, set forth the case for post-college education for engineers in his article in the JOURNAL of the Institute for April 1929, p. 310, and R. F. Schuchardt, then president of the Institute, gave further encouragement to the idea in his editorial on p. 259 of the same issue. The annual report of the committee on education under Professor Bennett's chairmanship was given in the JOURNAL for September 1929, p. 677, and amplifies the importance of stimulating interest in the systematic continuation of engineering education after college.

The Chicago Section actively took up the work of post-college education among engineers and has obtained surprisingly successful results. A progress report on activities of the education committee of this Section has been prepared by Burke Smith, chairman, and should be of interest to other Sections. The paragraphs following are taken from Mr. Smith's report:

An education committee for the Chicago Section was appointed in the summer of 1929 and has continued to function since that date. The committee at that time had no data to guide it, since no educational work of the nature here considered was being done by any engineering organization in Chicago. A questionnaire was sent to the membership requesting a reply from those members who would be interested in continuing their education by attending evening classes or lectures along certain specified technical lines. Out of some 1,200 members, replies were received from approximately 100, a rather meager response which in the light of the success of all courses offered indicates that questionnaires are of value only in so far as they are indicative of choice between different courses.

As a result of a preliminary study of the situation by the committee, the following conclusions were reached:

1. It appeared to be worth while to arrange for educational courses to be offered in the evening, a fee to be charged covering the cost of instruction.

2. While it is recognized that cultural subjects are of great value and interest to practising engineers, such subjects are offered by various educational institutions in Chicago or by correspondence courses and there appeared to be no need, therefore, for the Institute to arrange for courses of this nature.

3. It was felt that due to the limitations of the present 4-year engineering curriculum, practising engineers would be interested in technical subjects of a somewhat advanced nature which would supplement their undergraduate work.

4. In addition to the need for formal classroom work in advanced subjects, it was assumed that there is also a desire for lectures covering recent developments in physical science which would enable practising engineers to keep in touch with contemporary scientific progress.

5. It was proposed that any courses offered should be administered by an educational institution rather than by the Institute, thus relieving the Institute of the responsibility for arranging for instructors or lecturers, determining the form in which the subject matter should be presented, collecting fees, etc.

After a program of courses had been planned, it was decided to invite other engineering organizations in Chicago, such as the Western Society of Engineers and the Chicago Section of the Institute of Radio Engineers to join, so that a larger number of engineers might be interested and the enrolment in any courses offered might be increased correspondingly.

In accordance with the above policy, the following courses were offered, beginning in January 1930:

1. Engineering Economics. Classroom instruction, one session each week for ten weeks. This course was given by Armour Institute of Technology under the direction of Prof. E. H. Freeman; fee for the course, $10.

2. A lecture series on recent developments in electron physics and electrochemistry consisting of ten evening lectures, one per week, by members of the staff of the University of Chicago; fee for the series, $5. The following subjects were covered: the nature of the electron, the nature of heat, the nature of light, cosmical matter, molecular spectra and molecular structure, the arrangement in solids, modern theories of strong electrolytes, the electron in organic chemistry, the Werner coordination theory, and atomic species, isotopes and radioactivity.

The registration in engineering economics proved to be so large, 126 persons, that it was necessary to divide the class into two sections. Early in the fall of 1930 arrangements were made with Armour Institute of Technology to repeat the course, and a second class was organized with a registration of 39.

The registration in the lecture series on recent developments in electron physics and electrochemistry was 290. In view of the evident interest in these lectures an additional series of three lectures on electronics and three lectures on the theory of conductors and dielectrics was offered beginning in October 1930 and covering the following subjects:

Classical electron theory and positive rays, modern conceptions of the electron, television and the electron, conduction in gases, conduction in liquids and solids, and conduction in dielectrics

The registration for the first three lectures was 355 and for the last three, 208. The fee for each series of three lectures was $1.

The total number of registrations for the courses offered during the calendar year 1930 amounted to 1,018.

Activities during 1931 consisted of the following, all offered by the University of Chicago:

1. A classroom course in transient phenomena and advanced circuit theory offered in January in connection with the evening school which the University maintains in the downtown district of Chicago. The registration was 43, and the regular tuition fee of $12.50 for 12 weeks was charged. The University of Chicago does not have an engineering school, but arrangements were made to secure Prof. E. B. Paine of the University of Illinois as instructor.

2. A classroom course in modern circuit theory beginning in October and continuing for 24 weeks. The registration was 40, and the regular tuition fee of $25 charged.

3. A series of three lectures on acoustics given in October. Registration, 210. Fee for the series, $1.50.

All of the above courses were open to any who cared to register for them and were offered with the cooperation of the Chicago Section of the Institute of Radio Engineers and the Western Society of Engineers. From 28 to 38 per cent of those who attended were members of the Institute.

The question of fees was discussed with the educational institutions and the amount to be charged for each lecture series was determined on the basis of meeting expenses with the expected enrolment. It was understood that if expenses were not covered by the fees in the initial courses the Institute would share with the educational institutions in making up the deficit. For the classroom courses offered by the University of Chicago, it was understood that none would be given if a sufficient number of students was not enrolled at the first meeting to make it possible to meet expenses. Those who had not been enrolled previously in the University were charged a matriculation fee for these courses.

CONCLUSIONS

Based on the record of a registration of over 1,000 in the courses which were offered during 1930, and a continuation of interest during 1931, there can be no doubt that under the conditions existing in Chicago there is a desire for post-college evening courses of the following general nature:

1. Classroom work covering advanced subjects such as are usually given in resident post-graduate courses in mathematics, physics, and engineering subjects.

2. A connected series of lectures on selected topics in the physical sciences, given by specialists and designed to enable graduates to keep up with contemporary advances in these fields.

The question arises as to whether the demand for educational courses of the type described will continue. It seems that this will depend upon how well the local education committee succeeds in interpreting and putting into effect the wishes and needs of the members. Evening instruction in engineering subjects of an undergraduate level is not a new idea. That evening instruction of an advanced nature can be offered successfully over a period of years is shown by the experience of the Chicago Section of the American Chemical Society, which since 1923 has provided for its members instruction in advanced courses in chemistry, with results which have been uniformly successful. A description of this project is given in an article by Arthur Guilladeau and W. V. Evans in the *Journal of Chemical Education* for November 1928. Another example is that of the Polytechnic Institute of Brooklyn which for a number of years has maintained evening classes in engineering subjects of graduate level.

It is believed that if a definite sequence of courses is laid out requiring two or three

years for completion, there will be many engineers who will wish to enroll for the entire series. Such a sequence may be selected easily although obviously the particular courses which may be offered will depend upon the possibility of arranging for instructing personnel.

Following is a brief list of subjects which might form the nucleus of such a sequence. Many of these subjects are now offered as resident advanced courses in our larger engineering schools and universities. Some are more suitable for classroom work and others for a lecture series. The list of course could be greatly extended:

Engineering economics, differential equations for engineers, vector analysis with engineering applications, electric wave theory, Heaviside's operational calculus with applications, transient phenomena and advanced circuit theory, advanced theory of electrical machinery, theory of vacuum tubes and their circuits, acoustics, modern theories of magnetism, conduction of electricity through gases, modern theories of the electron, theory of conductors and dielectrics, the photoelectric effect, and the quantum theory of radiation.

Where facilities for experimental work and credit toward an advanced degree can be offered in connection with evening work a larger number of students will be attracted. Such facilities are available to evening students in only a few of the larger centers, however, and in most cases the instruction must of necessity be theoretical. In this connection it is possible that reading courses or a reading list service covering advanced subjects for the guidance of those engineers who do not live within easy reach of educational centers would be welcomed. At least one large university is now offering such a service to its alumni to enable them to follow a systematic course of reading in fields in which they are particularly interested. Results in Chicago to date indicate more interest in courses in pure science than in advanced engineering subjects.

It is well known that many industrial organizations offer technical training to their employees either in cooperation with the universities or as instruction courses under the direction of their own staffs. Such training is usually along special lines pertaining to the particular industry and does not supply the need for more fundamental courses or for work leading to an advanced degree. The educational activities of industrial organizations should supplement rather than conflict with any program which may be set up by the Institute Sections.

An educational program is a joint undertaking and in order to be successsful the responsibility for it must be shared by both the educational institutions and the engineers. There is ample evidence that the colleges and universities are alive to the situation and are willing to do their part. Now, therefore, is an opportune time for the Sections, through their education committees, to take the lead in making known their needs and developing plans to satisfy these needs in cooperation with the universities.

In conclusion, it may not be amiss to take stock of the results which may be expected to accrue over a period of years from a systematic educational program such as is here outlined:

1. The cooperation of educational institutions and engineering societies will result in a closer affiliation of all the groups concerned.

2. The engineers individually and the industries in which they are employed will gain from the further training and broader outlook of those who participate.

3. An increased appreciation of the value of the Institute to members and non-members alike will result.

In view of the evident desire on the part of practising engineers for a continuation of engineering education, and the future possibilities in this field, the statement from the report of the committee on education which was quoted at the beginning of this article does not seem to over-emphasize the importance of the movement and the need for adequate provision for a program of post-college education.

M.I.T. Plans New Division of Studies

The distribution of its curriculum into five distinct branches, namely, school of science, school of engineering, school of architecture, division of humanities, and division of industrial cooperation, was announced March 10, 1932, by Dr. Karl T. Compton, president of Massachusetts Institute of Technology. The following appointments have been made accordingly: Dr. Vannever Bush (A'15, F'24) a member of the faculty of electrical engineering since 1923, vice-president and dean of engineering; Dr. Samuel C. Prescott, dean of science; Prof. William Emerson, dean of architecture.

Doctor Compton is quoted as having stated that this new plan is a natural extension of an administrative plan started two years ago in the appointment of a chairman of the corporation and a president of the M.I.T. The new subdivision recognizes the five major aspects of the work, the three schools comprising those departments in which degrees are given, and the two divisions, essentially for "service" purposes, to give the students the benefit of a further cultural training and background deemed essential to a well-balanced training, and designed to make as effective as possible the assistance which the M.I.T. desires to render in various ways in solving the technical problems of business and industry.

What is counted an important feature of this new plan is definite recognition of the graduate school. With every evidence that this work is becoming relatively more and more important, it has seemed advisable to provide more adequately for its constructive administration through the establishment of a graduate school embracing

The Engineer—a Parable

ONE DAY three men, a Lawyer, a Doctor, and an Engineer, appeared before St. Peter as he stood guarding the Pearly Gates.

The first man to step forward was the Lawyer. With confidence and assurance, he proceeded to deliver an eloquent address which left St. Peter dazed and bewildered. Before the venerable Saint could recover, the Lawyer quickly handed him a writ of mandamus, pushed him aside, and strode through the open Portals.

Next came the Doctor. With impressive, dignified bearing, he introduced himself: "I am Dr. Brown." St. Peter received him cordially. "I feel I know you, Dr. Brown. Many who preceded you said you sent them here. Welcome to our City!"

The Engineer, modest and diffident, had been standing in the background. He now stepped forward. "I am looking for a job," he said. St. Peter wearily shook his head. "I am sorry," he replied; "we have no work here for you. If you want a job, you can go to Hell." This response sounded familiar to the Engineer, and made him feel more at home. "Very well," he said; "I have had Hell all my life and I guess I can stand it better than the others." St. Peter was puzzled. "Look here, young man, what are you?" "I am an Engineer," was the reply. "Oh yes," said St. Peter; "Do you belong to the Locomotive Brotherhood?" "No, I am sorry," the Engineer responded apologetically; "I am a different kind of Engineer." "I do not understand," said St. Peter; "what on Earth do you do?" The Engineer recalled a definition and calmly replied: "I apply mathematical principles to the control of natural forces." This sounded meaningless to St. Peter, and his temper got the best of him. "Young man," he said, "you can go to Hell with your mathematical principles and try your hand on some of the natural forces there!" "That suits me," responded the Engineer; "I am always glad to go where there is a tough job to tackle." Whereupon he departed for the Nether Regions.

And it came to pass that strange reports began to reach St. Peter. The Celestial denizens, who had amused themselves in the past by looking down upon the less fortunate creatures in the Inferno, commenced asking for transfers to that other domain. The sounds of agony and suffering were stilled. Many new arrivals, after seeing both places, selected the Nether Region for their permanent abode. Puzzled, St. Peter sent messengers to visit Hell and to report back to him. They returned, all excited, and reported to St. Peter:

"That Engineer you sent down there," said the messengers, "has completely transformed the place so that you would not know it now. He has harnessed the Fiery Furnaces for light and power. He has cooled the entire place with artificial refrigeration. He has drained the Lakes of Brimestone and has filled the air with cool perfumed breezes. He has flung bridges across the Bottomless Abyss and has bored tunnels through the Obsidian Cliffs. He has created paved streets, gardens, parks and playgrounds, lakes, rivers, and beautiful waterfalls. That Engineer you sent down there has gone through Hell and has made of it a realm of happiness, peace, and industry!"

By D. B. Steinman, President of the New York State Society of Professional Engineers, and Past-President of the American Association of Engineers. Reprinted from "The American Engineer" for January 1932.

engineering, science, and architecture. Notwithstanding this new subdivision, however, the faculty as a whole will continue to be the final authority in matters of educational procedure. The new organization provides for an administrative council, an informal organization which will hold weekly meetings in order to keep fully informed of the progress of various departments. This council will consist of President Compton, Vice-President Bush, members of the executive committee, Dean Prescott, Dean Emerson, the president of the alumni association, the chairman of the faculty, the director of the division of industrial cooperation, the deans of graduate students and students, and the bursar.

To Institute Members Planning Trips Abroad

Members of the Institute who contemplate visiting foreign countries are reminded that since 1912 the Institute has had reciprocal arrangements with a number of foreign engineering societies for the exchange of visiting member privileges, which entitle members of the Institute while abroad to membership privileges in these societies for a period of three months and members of foreign societies visiting the United States to the privileges of Institute membership for a like period of time, upon presentation of proper credentials. A form of certificate which serves as credentials from the Institute to the foreign societies for the use of Institute members desiring to avail themselves of these exchange privileges may be obtained upon application to Institute headquarters, New York. The members should specify which country or countries they expect to visit, so that the proper number of certificates may be provided, one certificate being addressed to only one society.

The societies with which these reciprocal arrangements have been established and are still in effect are: Institution of Electrical Engineers (Great Britain), Société Française des Electriciens (France), Association Suisse des Electriciens (Switzerland), Associazione Elettrotecnica Italiana (Italy), Koninklijk Instituut van Ingenieurs (Holland), Verband Deutscher Elektrotechniker E. V. (Germany), Norsk Elektroteknisk Forening (Norway), Svenska Teknologforeningen (Sweden), Stowarzyszenie Elektrykow Polskich (Poland), Elektrotechnicky Svaz Ceskoslovensky (Czechoslovakia,) The Institution of Engineers, Australia (Australia), Denki Gakkwai (Japan), and South African Institute of Electrical Engineers (South Africa).

Touring Arrangements for I.E.C. Congress.—For those going to the International Electrical Congress to be held this summer in Paris, France, provisions have been made with Thomas Cook & Son to provide transportation arrangements for those desiring to avail themselves of this service. According to the best information available, the congress will open Monday, July 4, 1932, and close July 12. Accordingly, Thomas Cook & Son thinks that the Cunard liner "S. S. Franconia," leaving New York, N. Y., June 24 and due to arrive at Havre, France, July 2, will be the most convenient and satisfactory vessel for such a party, and it already has reserved some space on this boat. The services of this organization also will be available for arranging subsequent tours in Europe, and to assist in securing passports, and supplying travelers' checks. Inquiries should be addressed to Thomas Cook & Son, either in Boston, New York, or other convenient cities, as early as possible.

Dr. W. D. Coolidge Receives Washington Award.—Following a dinner and reception February 24, 1932, at the Hotel Sherman, Chicago, Illinois, Dr. W. D. Coolidge (A'10) associate director of the research laboratory of the General Electric Company of Schenectady, N. Y., was presented the Washington Award for 1932, "in recognition of devoted, unselfish, and preeminent service in advancing human progress." Doctor Coolidge is to be the eleventh so honored by the award commission, the first presentation being to President Hoover in 1919. Dr. H. W. Chase, president of the University of Illinois, delivered the principal address of the evening, evaluating the importance of research in the present social order. Presentation of the award was made by F. D. Chase, president of the Western Society of Engineers, which administers this award founded 16 years ago by John Watson Alvord. A personal item containing news of this award to Doctor Coolidge was given in ELECTRICAL ENGINEERING for March 1932, p. 210–1.

Letters to the Editor

Discussion of "E.E." Articles Invited

Institute members and subscribers hereby are invited to discuss in these columns any of the articles appearing in ELECTRICAL ENGINEERING. Because of the many letters received, it is not feasible to publish all, but an endeavor will be made to include those which appear to be of the most general interest. The shorter letters in general are more popular; hence conciseness is a desirable quality in all cases. ELECTRICAL ENGINEERING reserves the right to publish letters either in full or in part.

Edison's Self-Consistency

To the Editor:

With all that we are saying and reading about our beloved Edison these days, a thought came to me that is quite different from those which I have heard expressed by any one. Others may have had it and not expressed it, fearing that it was pointing out a limitation in his efforts, and ability. To me, it shows his strength of character and good judgment.

At this time, when all his admirers are vying with each other in telling of his innumerable accomplishments, it may seem disrespectful to point out a field of electrical endeavor that he consistently avoided. Edison unquestionably appreciated that to succeed in any line even he must be enthusiastic, and his early commercial fight with those who pioneered in a-c. development naturally left him without enthusiasm in this direction.

A lesser mind, as the commercial possibilities of alternating current rapidly developed, would have been tempted to join in the effort and thus share in the commercial rewards. Not so for Edison, who was always true to himself. The pioneer inventors and engineers who were working with a-c. generators, motors, and transformers would have had a formidable competitor in Edison had he decided to enter this field. He evidently decided that he had abundant opportunities elsewhere.

Is there not in this a lesson teaching the young engineer to select, if possible, lines of work that appeal to his enthusiasm rather than some that give perhaps better immediate prospect of higher financial returns? One must obtain unusual results to get superior rewards and such results are seldom attained without the assistance of enthusiasm.

Very truly yours,
WALTER S. MOODY (F'12)
(Consulting Electrical Engineer, 155 Dawes Ave., Pittsfield, Mass.)

Diversification in Articles Commended

To the Editor:

The letter of protest tendered by Mr. F. G. Strong of Wethersfield, Connecticut, against the article "Nerve Injuries from Electric Shock," and appearing in ELECTRICAL ENGINEERING (Feb. 1932, p. 138) is at once a concentrated source of astonishment and argument to me.

This attitude seems to fortify the impression gained by me during the past two years that ELECTRICAL ENGINEERING and its predecessor, the JOURNAL of the A.I.E.E, caters primarily to the power aspects of the electrical engineering profession. The appearance of the aforementioned article and various others of its type, not necessarily dealing with the medical aspects of electricity, has accomplished a great deal in dispelling this illusion from my mind.

With due respect for Mr. Strong's more experienced viewpoint, I nevertheless desire to commend ELECTRICAL ENGINEERING in its display of the appreciation that the electrical engineering profession does not comprise a group of power engineers solely; but, that it also includes engineers associated with a multitudinous array of other valuable applications of that wonderful realm of reality—Electricity.

Very truly yours,
M. K. KUNINS (A'32)
(Jr. U.S. Radio Inspector, Radio Div., Dept. of Commerce, Buffalo, N. Y.)

Unity Power Factor for Neon Tube Signs

To the Editor:

The article by McNeely and Law entitled "Unity Power Factor for Neon Tube Signs" and appearing in the November 1931 issue of ELECTRICAL ENGINEERING, p. 886–8, leaves the reader with the impression that the constant current circuit is the best and most economical solution, in all cases, of the problem of producing luminous tube signs with high power factor. I am writing to point out some of the reasons why this circuit has not been generally adopted.

The data given by the authors relates to the special case of a small sign with a fixed load of tubing. It is not indicated whether calculations or tests were made on larger signs and transformers with varying lengths of tubing. From the data given it appears that the tests reported were made on transformers of about 2,500 volts open circuit, delivering 15 milliamperes to the tubing. Such transformers are generally used with small window or show-case signs, and because the load taken by them is small and they are usually connected to circuits carrying a relatively large load of incandescent lighting, the power factor of the individual sign is not of great importance.

The problem of power factor is most important in the case of large signs which employ transformers of 12,000 or 15,000 volts open circuit rating, delivering approximately 25 milliamperes to the tubing. There are some problems encountered with these larger transformers which do not apply to the smaller, lower voltage units.

As the authors point out, when the constant current circuit is employed the transformer primary winding will take a substantially constant current, even when the secondary of the transformer is open-circuited. Under these conditions the entire current becomes exciting current, and the secondary voltage is limited only by the saturation of the core. Since it is not feasible to insure that the transformer may never be operated with open-circuit, the use of the constant current circuit therefore involves a serious hazard to the insulation of the transformer, and the cable, electrodes, etc., in the sign. Furthermore, the open-circuit voltage of transformers used in luminous tube signs is definitely limited by the National Electrical Code.

In determining the amount of capacity required to obtain maximum power factor correction with commercial transformers the authors have evidently connected the capacitors directly across the 110-volt circuit. They have not taken account of the generally accepted arrangement of operating the capacitor at higher voltage, using the primary winding of the transformer as an auto-transformer to obtain this voltage. Since the corrective effect of a capacitor is proportional to the square of the voltage, this arrangement results in substantial economy. A 15,000-volt 25-milliampere transformer carrying a normal load of tubing, can be made to operate at a power factor well over 90 per cent by the use of as little as 5μ of capacity operating at about 500 volts. Of course the capacitor must be suitable for use on this voltage, but most modern capacitors are, and because of mechanical limitations, very little can be gained by rating them at a lower voltage.

The fact that the installation using the constant current circuit can, and probably must, be made up of several individual devices, is likely to prove a disadvantage rather than an advantage. In the case of small window or show-case signs it is desirable that the sign manufacturer assemble the sign complete, leaving the installation job as simple as possible. In the case of large outdoor signs, this is also true, with the additional consideration that such signs frequently contain many transformers, and the use of separate reactors and capacitors installed inside the building, with separate circuits to the individual transformers would be prohibitive because of cost and complication.

A capacitor sufficient for power factor correction can be placed in the same case with the conventional transformer, with a small increase in one dimension only, providing a self-contained high power factor unit, interchangeable as to mounting dimensions with the conventional low power factor transformer.

Still another difficulty that might be expected with the constant-current circuit results from the fact that many of the higher voltage transformers are operated with the midpoints of the secondary windings grounded, in order to limit the voltage that may be applied under abnormal conditions to the tubing and other parts of the circuit. Accidental grounds may, and do, occur in the high voltage circuit. With the conventional high reactance transformer the current in the winding thus short-circuited is limited by the impedance of the transformer to a safe value. With the constant-current circuit, the primary would continue to force a definite number of ampere-turns through the secondary winding, these ampere-turns dividing between the two halves of the winding in inverse proportion to the impedances.

With one half of the winding short-circuited and the other half open-circuited or loaded, the short-circuited half would supply most of the ampere-turns, with resulting over-load and probable burn-out.

Very truly yours,

R. H. CHADWICK (A'17, M'26)
(Engineer, Transformer Division, General Electric Co., Fort Wayne, Ind.)

Electrical Precipitation

To the Editor:

In connection with the article "Electrical Precipitation," by Simon and Kron, which appeared in the February issue of ELECTRICAL ENGINEERING, p. 93–5, I desire to point out a few of the results which have been obtained in the development of theory and technique by those scientists and engineers who have devoted so much effort to this art during the past twenty years, both here and abroad.

To mention but one of the many studies which have been made, E. Anderson and other engineers of the Western Precipitation Company carried on extensive experiments at Santa Cruz in 1919, using not a single size pipe electrode as reported by Simon and Kron, but 3-in, 4-in., 6-in., 9-in., and 12-in. tubes of from 5 ft. to 20 ft. in length. One of the many important results of this particular study was the development of a formula for precipitator efficiency, $\eta = 1 - K^t$, in which K is a "constant." Simon and Kron use a constant α. If we let $K = e^{-\alpha}$ we find the formula developed by them to be identical with that of Anderson and equivalent to similar formulas developed by various European investigators, notably Heinrick and Deutsch.

It must be emphasized, however, that the manner in which this formula is used is of vital importance. A point long recognized by precipitation engineers but overlooked in the reports of the Simon and Kron investigation is the fact that the "constant" α (or K) is not nearly so constant as might be desired; nevertheless, the formula is used continually in precipitator design, but always with due consideration of its recognized limitations. These limitations have made those who best appreciate them extremely hesitant in the publication of their results.

The apparatus used for the measurement of dust concentration and described by Simon and Kron, is not used in electrical precipitation investigation because of its inherent inaccuracy as a gage of dust content when there is a variation in the size of the dust particle. It has been reported by Tolman (*Journal of American Chemical Society*, V. 41, 1919, p. 307) that the light beam strength through a dust laden gas varies with the concentration of dust between limiting formulas in which, for small particles, the particle diameter appears directly as the cube, and for the large particles inversely as the first power. The Tyndall beam type of instrument is therefore of little value in the comparison of inlet and outlet concentrations if there is any marked change in the dust particle size between the two points of measurement. An electrical precipitator will produce such a change in dust particle size to a very marked degree, especially in the case of particles of the kind used by Simon and Kron.

This fundamental characteristic of the measuring device is doubtless responsible for the difference which exists between the conclusions reached by Simon and Kron and the facts established by engineers and scientists who, under the auspices of Lurgi Apparatebau-Gesellschaft, Siemens-Schuckertwerke, Lodge-Cottrell, Ltd., Western Precipitation Company, and Research Corporation, have been working on this problem for more than a score of years. I refer especially to the statement that efficiency is a positive exponential function of the current and the statement that the voltage, in so far as it affects the electrical field, has little effect on efficiency.

Very truly yours,

J. C. HALE (A'10, M'29)
(Electrical Engineer, Research Corp., Bound Brook, N. J.)

Has Man Benefited by Engineering Progress

To the Editor:

Responding to the invitation to submit comments on the question "Has Man Benefited by Engineering Progress" I am impressed by the letter of Professor Rittenhouse, in ELECTRICAL ENGINEERING, January 1932, p. 59, as discussion of the question can run riot in the absence of more exact definition. If man is benefited by cheap bathtubs, talkies, radio crooners, automobiles, etc., there is no room for discussion. Science and engineering gave these and some others less pleasant to contemplate. If, however, benefit to mankind results from cultivation of what is beautiful, using the word in its broadest sense, and suppression of what is ugly in the world and in human relations, the question becomes debatable. It might be possible to prepare an impressive argument to show that man would be better off if every child born with a scientific mind had died in infancy. What is the formula for human benefit? *Homo sapiens* is treated in the mass in government statistics, but individually he is everything from the noblest to the lowest of earthly creatures. Anything that promotes a higher average of

character and mentality would be a benefit, and perhaps engineering has helped in this direction.

Mr. Kohn wants engineers to "work out a new vision of human relations" but that does not seem to be a hopeful job for the profession. I wonder if a brand new engineering vision would be more popular than that given in "The Sermon on the Mount." From a practical point of view, would it not be better to do less dreaming about a new social scheme, and more hard work to make the existing scheme better?

The membership of our national organizations constitutes a great body of skilled engineers and a host of men of wide practical business experience. They and their predecessors have given the United States the machine age civilization that is so much admired. They should be worshipped as were the priests of Ammon; but on the contrary the public and the politicians treat them rather like djinns ordered out to perform miracles, which, these being done, are stored away in bottles. If the symposium includes the question as to what engineers should do to benefit mankind, then I suggest that American engineers try to break out of the bottle and take their proper place in public affairs. Vast sums have been, are being, and will be, squandered on governmental projects that come directly within the province of engineers. The people naturally cannot form an intelligent opinion of such undertakings, those who should guide them are ignored, and the political promoters have their way. I cannot do better than to refer to the address on this subject by W. S. Lee, published in ELECTRICAL ENGINEERING for August 1931, p. 641–2. It seems to be a sad fact that the engineer has no real standing with the American public. True, we have an engineer as President of the United States; but did that fact count in his election? I doubt it, for he gets no consideration as such, and if instead he had been a first-class politician, he would probably have had better support. If engineers enjoyed public esteem, would it not have been a natural procedure to leave, so far as possible, any purely engineering question to the judgment of an engineer president? The prolonged inane discussions of Muscle Shoals in Congress is a case in point. Any competent engineer could have cut that discussion short with a few facts; but none was given the opportunity. This country has the most highly developed electric power supply in the world, and consequently, an abundance of experts on the subject; yet the United States Senate seriously discussed supplying electricity to the public from that chunk of concrete in the Tennessee River, where the flow is as unreliable as German reparations. Public waste makes private want, and engineers can benefit mankind as represented by the people of the United States if they can find a way to establish an influence in such public affairs as are in their own field, and respecting which they only are competent to form sound decisions. I do not know how this can be done, but it is well worth our attention both as engineers who detest economic crimes and as patriotic citizens. It might be worth while first to try to discover why engineers are not consulted in advance on government projects, as they are in similar private undertakings? Perhaps it is because our profession is too modest or too timid to proclaim the truth so that the taxpayer may at least know in advance what is coming to him. Mr. Hoover recently said that our governments, federal, state, etc., are "engaged in constant attempt to solve a multitude of public relationships to these tools which the engineers. .constantly force to the very doorstep of the government;" to which he added "These problems of public relations are unsolvable without the technical assistance of the engineer himself." In concluding his address the President of the United States insisted that engineers have the obligation to contribute to the public service. If we have the ability, persistence, judgment, and perhaps self-sacrifice to take on the obligation, we may then benefit our countrymen, if not all mankind.

Very truly yours,

F. V. HENSHAW (A'89, M'95, Member for Life) (Wood, Struthers, & Co., 20 Pine St., New York, N. Y.)

Speakers for Washington Bicentennial Celebrations

During the remainder of 1932, many celebrations will be held in commemoration of the 200th anniversary of the birth of George Washington. The American Engineering Council is preparing a list of speakers who are especially qualified to address engineering groups upon the engineering features of George Washington's career, and has requested the Institute to supply some names.

Members of the Institute who would be willing to prepare such addresses to be delivered in their localities are requested to send prompt notification to Institute headquarters, 33 West 39th St., New York, N. Y.

Specifications for Electrical Heating Elements.—The American Society for Testing Materials is seeking comments on two recently adopted specifications, as follows: tentative specifications for "Drawn or Rolled Alloy, 80 per cent Nickel, 20 per cent Chromium, for Electrical Heating Elements" (B82–31T) and "Drawn or Rolled Alloy, 60 per cent Nickel, 15 per cent Chromium, and Balance Iron, for Electrical Heating Elements" (B83–31T). Comments on tentative method of "Test for Determining the Temperature-Resistance Constants of Resistance Alloys" (B84–31T) are also requested. Communications relative to the above should be addressed to R. E. Hess, American Society for Testing Materials, 1315 Spruce Street, Philadelphia, Pa., from whom copies of the specifications may be obtained.

American Engineering Council

Study Being Given Muscle Shoals Legislation

Dr. H. E. Howe of Washington, D. C., Prof. Charles F. Scott (A'92, F'25, HM'29, and past-president) of Yale University, New Haven, Conn., and J. Dyer of Nashville, Tenn., have been appointed by the American Engineering Council to study the Muscle Shoals measure introduced in the House by Representative E. B. Almon of Alabama.

The purpose of the Almon bill is, first, to aid American agriculture and to provide for national defense by the employment of the Muscle Shoals project, privately operated primarily for the production of fertilizer; and second, to make available for the production of chemical products any surplus of the Government owned resources.

The bill would create the Muscle Shoals Corporation of the United States, the directors of which would be authorized to lease for not more than fifty years the Muscle Shoals properties of the government. It also provides for an appropriation of $5,000,000 to build Cove Creek Dam.

The American Engineering Council, it was also announced, is opposed to the Muscle Shoals legislation sponsored by Senator George W. Norris of Nebraska "to provide for the national defense by the creation of a corporation for the operation of the government properties at and near Muscle Shoals in the state of Alabama, to authorize the letting of the Muscle Shoals properties under certain conditions, and for other purposes." This resolution was reported in the Senate, March 9, 1932, by the committee on agriculture and forestry. A similar resolution by Representative W. F. James of Michigan has been referred to the committee on military affairs of the House. These resolutions are identical and contain approximately the same proposals as the legislation which passed the Seventy-first Congress and was vetoed by the President.

Engineering Foundation

Plans for Study of Industrial System Discussed

At a dinner meeting of the Engineering Foundation on February 18, 1932, in New York, N. Y., consideration was given to plans for a study of the industrial system. Representatives from the American Engineering Council, the planning committee, United Engineering Trustees, Inc., and the Engineering Foundation, together with several special guests, brought the total attendance to 37.

For several years there has been a growing sense of obligation among members of the Engineering Foundaton to undertake from the engineer's point of view, research bearing upon economic and other humanistic problems. In September 1931, the United Engineering Trustees, Inc. submitted a proposal for a study of the industrial system to the Foundation, and the latter has since been giving the subject earnest consideration. The planning committee appointed is cooperating with the American Engineering Council.

Valuable suggestions were offered during the discussion at this meeting, and the need for a thorough study was emphasized. Definite suggestions were made and the desirability of cooperating with members of other professions was brought out. However, the valuable background of thought, habit, and experience of the engineer should be the center around which this cooperation should be built up. The necessity for courage and determination in the study of industrial problems was emphasized by several of the discussers, all of whom agreed as to the tremendous benefits which may be secured from such a study.

Annual Report Issued by United Engineering Trustees, Inc.

IN THE annual report of United Engineering Trustees, Inc., for 1931, submitted by John V. N. Dorr, president, and Alfred D. Flinn, secretary, it is pointed out that the assets for which the corporation is responsible total $3,425,957.52, exclusive of the library and the John Fritz Medal fund. The report also mentions that outstanding among events of 1931 was the fourth gift of Ambrose Swasey, founder of the Engineering Foundation; this gift of $250,000 raised the total to three-quarters of a million dollars. Through the will of E. H. McHenry, a well-known consulting engineer, late of Philadelphia, Pa., Engineering Foundation benefited to an additional amount estimated at approximately $400,000.

Early in November, United Engineering Trustees, Inc., consented to serve as treasurer and accountant for the Professional Engineers Committee on Unemployment. It is continuing to perform these services.

The development committee in December submitted a full report of its extensive studies for providing needed additional accommodations for the engineering societies. The Engineers' Club joined in this work which was devoted largely to a scheme for an "engineering center" but owing to business conditions no active steps are now feasible.

Through recommendation of the Trustees, Engineering Foundation in examining the possibilities of an engineering study of the industrial system. In passing to the summary of the financial report, it is worthy of note that all departments again closed the year without deficits.

Summary of 1931 Financial Report

Operation of Building		
Credit Balance January 1, 1931	$10,636.73	
Less Adjustment 1930	−25.00	$10,611.73
Building Revenue 1931	126,837.37	
Building Expenditures 1931	115,546.96	11,290.41
Total		$21,902.14
Annual Payment to Dep. and Renewal Fund	$12,000.00	
Payment to Reserve for Future Fire Insurance	1,550.00	13,550.00
Credit Balance December 31, 1931		$8,352.14
Operation of Library		
Maintenance Revenue	$50,674.96	
Maintenance Expenditures	52,011.70	
Debit Balance for year 1931	−1,336.74	
Credit Balance from preceding years	5,688.95	
Total Credit Balance December 31, 1931		$4,352.21
Service Bureau Revenue	$17,031.56	
Service Bureau Expenditures and Adjustments	17,422.17	
Debit Balance for year 1931	−390.61	
Credit Balance from preceding years	4,733.96	
Total Credit Balance December 31, 1931		$4,343.35
Funds and Property		
Funds held by U.E.T., Inc. Dec. 31, 1931 (book value)		
Depreciation and Renewal Fund		$303,397.14
General Reserve Fund		3,934.40
Engineering Foundation Fund		529,283.65
Engineering Foundation Fund (4th Swasey Gift)		253,696.50
Henry R. Towne Engineering Fund		50,115.63
Library Endowment Fund		174,544.32
Edward Dean Adams Fund		100,000.00
Total		$1,414,971.64
Real Estate owned, cost to Dec. 31, 1931		$1,987,793.92
Operating cash and petty cash		10,092.63
Accounts Receivable		5,585.83
Endowment Committee Loan Receivable		1,700.00
Unexpired Fire Insurance Premiums		1,213.50
Fire Insurance Fund		4,600.00
Total Property which U.E.T., Inc. owns or holds		$3,425,957.52
Value of Library (as appraised approximately for Insurance)		$483,000.00
John Fritz Medal Fund (Custodian)		3,500.00

Election Held by Engineering Foundation

At its annual meeting February 18, 1932, the Engineering Foundation board reelected as its chairman H. Hobart Porter (A'96, M'12, Life Member) president of the American Water Works and Electric Company, Incorporated, New York, N. Y.; George W. Fuller, consulting engineer, former vice-president of the American Society of Civil Engineers, New York, N. Y., and a member of the firm of Fuller and McClintock, was made vice-chairman. Second vice-chairman is C. E. Skinner (A'99, F'12) president of the A.I.E.E., and assistant director of engineering for the Westinghouse Electric and Manufacturing Company, E. Pittsburgh, Pa. George D. Barron, mining engineer, of Rye, N. Y., and D. Rovert Yarnhall, of Philadelphia, Pa., vice-president of the American Engineering Council, were elected to the executive committee. Dr. A. D. Flinn continues as secretary and director.

New members and reelected members of the Engineering Foundation board whose terms began at the annual meeting on February 18, 1932, are E. De. Golyer, New York, N. Y.; H. P. Charlesworth (F'28) representing the A.I.E.E., New York, N. Y.; E. R. Fish, Hartford, Conn.; G. G. Crawford, Pittsburgh, Pa.; H. Hobart Porter (M'12) New York, N. Y.; and H. A. Kidder (F'29) New York, N. Y.

Personal

A. S. Miller (A'08, F'12) vice-president of the Bartlett Hayward Company, engineers, New York, N. Y., at the January 14, 1932 meeting of the Engineering Societies Library board was reelected chairman and W. I. Slichter (A'00, F'12) was made vice-chairman. Mr. Miller is a native of Richmond, Virginia; since his graduation from Stevens Institute of Technology in 1888 he has had extensive experience in public utilities. In 1911, with Dr. A. C. Humphreys he formed the consulting firm of Humphreys and Miller, Incorporated, an activity which he continued until 1918 when he became vice-president of the Bartlett Hayward Company. He was appointed to the library board by the American Society

of Mechanical Engineers. Professor Slichter, already well known in the annals of the A.I.E.E. as manager (1918–22) vice-president (1922–24) and an active worker on several of its committees, was born in St. Paul, Minn. Immediately after graduation from Columbia University in 1896 he entered the employ of the General Electric Company at Schenectady as a student. Shortly thereafter he was transferred to the office of Dr. C. P. Steinmetz to engage in experimental work, tests, and calculations on a number of subjects. For several years he served the Society of Engineers of Eastern New York as treasurer. His contributions to technical literature have been many.

VANNEVAR BUSH

Dr. Vannevar Bush (A'15, F'24) since 1923 a member of the faculty of electrical engineering of Massachusetts Institute of Technology, Cambridge, Mass., recently was elevated to his new office of vice-president and dean of engineering, according to appointments announced March 10, 1932. He is a native of Everett, Mass., a graduate of Tufts College (1913), and holds a degree of doctor in engineering from Harvard University and from M. I. T., where his work has been noteworthy in research achievements and contributions to technical education. He has been interested particularly in the design of scientific calculating instruments, and for the development of the product integraph in 1928 was awarded the Levy Medal of the Franklin Institute. Not long since he won recognition for his design of an intricate calculating machine called the differential analyzer, which greatly increases the accuracy and speed of engineering calculations. He is also known for his contributions to the development of vacuum tubes and his investigations in electric power transmission. Under his direction at M. I. T. has been built another instrument known as the network analyzer, a device upon which a power network covering several states may be reproduced accurately and operating characteristics studied under most satisfactory conditions. Important branches of study carried on by Doctor Bush have been those of transients in machines, and dielectric phenomena. His career as a teacher has been no less notable than has his work in research; he has been professor of electrical transmission and for sometime was in charge of graduate study and research in the department. Early in his career he held a position in the test department of the General Electric Company, returning to Tufts College as an instructor in mathematics; from this position he was subsequently advanced to that of assistant professor of electrical engineering. Following the World War during which he did valuable research work on the detection of submarines for a special board of the United States Navy, he was consulting engineer for the American Radio and Research Corporation. He is a director of the Spencer Thermostat Company, Cambridge, Mass., and of Raytheon Incorporated of Newton, Mass. He is a Fellow of the American Academy of Science, and of the American Physical Society; a member of the Society for the Promotion of Engineering Education, and the author of numerous contributions to scientific and engineering literature. The book "Principles of Electrical Engineering" written in joint authorship with Professor W. H. Timbie is probably one of the most widely used books in its field.

H. Hobart Porter (A'96, M'12) president of the American Water Works and Electric Company, Incorporated, New York, N. Y., and a Life Member of the Institute, was reelected chairman of the Engineering Foundation at its annual board meeting Feb. 18, 1932. The Foundation is the research organization of the national societies of civil, mechanical, mining and metallurgical, and electrical engineers, with headquarters in the Engineering Societies Building, 33 West 39th Street, New York. Mr. Porter, who is chairman also of the board of the West Penn Electric Company and a director of numerous railroad and public utility enterprises, is a former trustee of Columbia University and a former president of the University Club, New York City. As a member of the firm of Sanderson and Porter, New York, he was engineer of the large hydroelectric development in California of the Stanislaus Electric Power Company, later known as the Sierra and San Francisco Power Company. Power was transmitted 140 miles at 110 kv. to serve the United Railways of San Francisco. This was one of the first 110-kv. transmission lines over so great a distance and involved many original problems. For some years Mr. Porter was one of the consulting engineers for the Interborough Metropolitan Railway Company; his work on many important investigations and as an engineer in charge of large operations was given high commendation, and products of his professional ability have been demonstrated in design and construction developments in many states: in the hydroelectric development for the Inland Empire Railway System, Spokane, Washington, the Twinbranch power plant and transmission system for the Indiana and Michigan Electric Company, South Bend, Ind., the steam power plant and transmission system for the New Hampshire Traction Company, Portsmouth, N. H., two steam power plants for the New Orleans Railway and Light Company, New Orleans, La., and several Connecticut developments of important tramways.

H. H. PORTER

Gerald Deakin (A'07, M'13) who was first assistant chief engineer of the International Telephone and Telegraph Company, New York, N. Y., now is in London in the capacity of vice-president and European technical director of the International Standard Electric Corporation.

Walter Steinkamp (A'26) previously district manager of the Picker X-Ray Corporation, Buffalo, N. Y., recently became secretary and general manager of James Picker, Inc., and Waite & Bartlett X-Ray Manufacturing Company, both of Cleveland, Ohio.

H. L. Olesen (M '27) formerly sales and contact engineer of the Jewell Electrical Instrument Company, Chicago, Ill., now is manager of the radio sales division of the Weston Electrical Instrument Company, Newark, N. J., in charge of the combined radio lines of the Jewell and Weston companies.

H. N. Hardsog (A'25) in the past designing engineer with the Narragansett Electric Company, Providence, R. I., on February 8, 1932, became power engineer for the Fall River Light Company, Fall River, Mass., both companies being controlled by the New England Power Engineering and Service Corporation.

Stuart Wilder (A'02, M'13) vice-president of the Westchester Lighting Company, Mount Vernon, New York, and a past-president of the Empire State Gas and Electric Company, recently was chosen a vice-president of the Yonkers Electric Light and Power Company. Mr. Wilder's record with the Westchester Lighting Company dates from 1903 when he joined the company as assistant chief engineer of the electrical department.

G. B. Kirkwood (A'25) previously district sales manager of the New York, N. Y., sales office of the Pacific Electric Manufacturing Corporation, has been transferred to Los Angeles, Calif., to succeed L. C. Williams (A'15, M'26) district manager of the latter office, who has been quite ill of late. Mr. Kirkwood has been engaged in the design and sale of high tension switchgear and protective devices with the Pacific Electric Manufacturing Corporation since 1913, having served successively as shop workman, draftsman, chief draftsman, on costs and estimates, and since 1924 dis-

trict sales manager. He has been in the San Francisco, Calif., Los Angeles, Calif., Chicago, Ill., Gary, Ind., New York, N. Y., and now the Los Angeles offices of the company.

A. K. MacNaughton (A'21, M'26) who has been with the Georgia Power Company, Atlanta, Ga., as electrical engineer, now has joined the Commonwealth and Southern Corporation, Alabama Power Building, Birmingham, Ala.

J. L. Sherwin (M'30) who has been serving the H. K. Ferguson Company, at Cleveland, Ohio, as electrical engineer, now has gone into business for himself in that city, and will specialize in power plant and industrial engineering reports and design.

A. E. Pope (A'07) vice-president of the New England Power Association, Boston, Mass., has been elected president of the New England Power Company, Worcester, Mass., the association's principal wholesale generating and distribution unit in central New England.

U. N. Halliday (A'28) who has been district sales manager of the Portland territory of the Pacific Electric Manufacturing Corporation, is being transferred to Salt Lake City, Utah, to open a new branch sales office there. His territory will consist of Utah, Idaho, Montana, Wyoming, and Colorado.

E. H. Rosenquest (A'03) president of both the Westchester Lighting Company, Mount Vernon, N. Y., and the Bronx Gas and Electric Company of New York City, and recently elected president of the Yonkers Electric Light and Power Company, was made a director of the United Electric Light and Power Company at a recent meeting of its board.

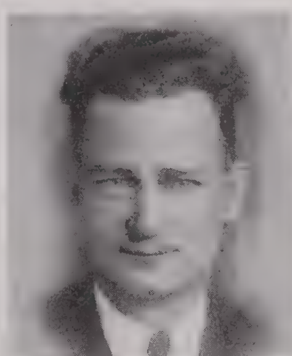
C. H. Cutter (A'28) formerly district sales manager for the Pacific Electric Manufacturing Corporation at Seattle, Wash., has recently been placed in charge of the Portland, Ore., territory for the company. His headquarters will remain at Seattle. Mr. Cutter has been with the Pacific Electrical Manufacturing Corporation since 1921, having served as assistant to the superintendent, purchasing agent, and advertising manager previous to becoming district sales manager.

Kline Gray (A'24) who has been handling the sale of Ward Leonard products for the past seven years with the Westburg Engineering Co., Chicago, Ill., has been appointed Chicago district manager of the Ward Leonard Electric Company. In an effort to better serve this important territory, F. E. Beede, sales engineer of the Ward Leonard company, will be transferred from the factory organization to the Chicago staff. This change has been occasioned by the appointment of P. A. Westburg (A'07, M'16) as Chicago district manager of the Weston Electrical Instrument Corporation.

W. A. DelMar (A'06, F'20) chief engineer of the Habirshaw Cable and Wire Corporation, Yonkers, N. Y., Prof. W. I. Slichter, of Columbia University, W. B. Jackson (A'97, F'13) rate engineer, New York Edison Company, New York City, and W. S. Barstow (A'94, F'12) president of W. S. Barstow and Company, New York, N. Y., have been elected to serve as A.I.E.E. representatives on the library board of the Engineering Societies Library for the year 1932.

J. J. Orr (A'30) plant engineer of A. J. Brandt, Incorporated, Detroit, Mich., has removed to New York City, where he is electrical engineer for the United States Rubber Company. Mr. Orr has specialized in industrial power engineering and supervised the design and installation of the complete electrical system in the General Motors plant at Pontiac, Mich., the American Austin Car Company at Butler, Pa., and the "Amo" Auto Works at Moscow, U. S. S. R.

H. R. Woodrow (A'12, F'23) at a recent election of officers for the Brooklyn Edison Company was made vice-president in charge of electrical operations. He is a native of Rock Rapids, Ia., and a graduate of the University of Illinois (1909). Prior to 1917, Mr. Woodrow was assistant chief electrical engineer of the New York Edison Company with which he has been identified since 1911. As an assistant to Mr. Philip Torchio he was associated with various developments and investigations, and in his



H. R. WOODROW

appointment as assistant chief electrical engineer he kept closely in touch with the design and operation of all generating and substations of the company. In 1922 he became assistant electrical engineer of the Brooklyn Edison Company, associated with J. C. Parker, recently elected to the presidency, and in this connection demonstrated extraordinary practical judgment, analytical ability and initiative in connection with the electrical design of generating stations, transmission systems, substations, and distribution systems. He has always taken a very active interest in the field of protective devices and for five years served on the Institute's committee on protective devices. He has served also on the A.I.E.E. membership, meetings and papers, standards, and power transmission and distribution committees, the last of which he was chairman 1928–30; at present he is a director and serving also on the publication committee Mr. Woodrow was identified in a consulting capacity in the design of the Trenton Falls and Washington Street station at Dayton, Ohio, the Williamsburg station of the Brooklyn Rapid Transit Company, and the government plant at Nitro, Va. His transfer to the grade of Fellow endorsed by Benjamin G. Lamme included the statement, "I have been in direct contact with Mr. Woodrow's work for many years in engineering problems requiring advanced knowledge of electrical theory and practise in the application of electrical apparatus, and have found him a man of very great knowledge and ability."

G. L. KNIGHT

G. L. Knight (A'11, F'17) mechanical engineer of the Brooklyn Edison Company, Brooklyn, N. Y., for many years, and prior to his appointment as such, design engineer for that company, was chosen by recent election to be its vice-president in charge of mechanical operations. Born at Haddonfield, N. J., Mr. Knight was graduated from Drexel Institute in both mechanic arts (1898) and electrical engineering (1900). In 1902 he was manager of the Walker Electric Company of Philadelphia, Pa. For two years he was chief draftsman of the New York Edison Company prior to his transfer to the Brooklyn Edison Company in 1905 in like capacity. In 1908 he was made designing engineer, the position he occupied until 1924 when he became mechanical engineer. He has done no inconsiderable special electrical, mechanical, and civil engineering work in connection with the construction of large central stations, from the laying of their heavy foundations and condensing tunnels straight through to the completion of stations ready to operate, and the complete design and construction of substations, storage yards, and office buildings. His committee work with the Institute has been abundant; he has served on the following committees: standards 1914–25; board of examiners, 1922–4, 1928–9; finance, 1922–8; executive, 1923–8; headquarters, 1923–8; coordination of Institute activities, 1923–6, 1927–8; Edison Medal, 1926–8; meetings and papers *ex-officio* 1927–8; and power generation, 1927–9. He was a member of the U.S. national committee of the International Electrotechnical Committee, 1923–6; and a member of the board of trustees of the United Engineering Trustees, 1926–31. Besides his committee work, Mr. Knight has served the Institute as a manager 1922–6, and a vice-president, 1926–8.

Harry B. Smith (A'28) who has been serving the Northern Electrotype Company of Detroit, Michigan, as mechanical engineer, has been made a vice-president of the American Electrotype Company, also in Detroit.

H. S. Falk (A'08) vice-president and general works manager of the Falk Corporation of Milwaukee, Wis., was elected a director of the Heil Company of that city at a recent meeting of the board.

H. M. Brinckerhoff (M'26) of the firm of Parsons, Klapp, Brinckerhoff and Douglas, of New York, N. Y., has been appointed a member of the city plan commission of Englewood, N. J.

R. C. Young (A'29) previously district manager for the Kuhlman Electric Company, Atlanta, Ga., has been transferred to the Chicago, Ill., territory of the company where he will continue as district manager.

F. J. Cornford (A'23) who was construction superintendent for the Ohio Power Company, Philo, Ohio, now is construction engineer for the Scranton Electric Company at Pittston, Pa.

D. C. Harker (A'27) who was a general engineer for the Westinghouse Electric and Manufacturing Company, Detroit, Mich., now has joined the Hudson Motor Car Company in that city as engineer.

G. J. Lexa (A'20) electrical engineer, Harnischfeger Corporation, Milwaukee, Wis., recently changed his affiliations and became electrical engineer of the Lakeside Bridge and Steel Company of that city.

A. E. Waller (A'12, F'21) priorly associated with the General Cable Corporation, now has joined the Sundh Electric Company of Newark, New Jersey, as sales engineer.

P. J. Ost (M'23) who served the City of San Francisco as its chief electrical engineer now has taken a similar position with the Public Utilities Commission of San Francisco, Calif.

F. W. Willis (A'04, F'19) who served as local Honorary Secretary of the Institute for India from 1925 to 1930, has retired from active service in India and is now residing in Auckland, New Zealand.

Obituary

Frank George Baum (A'99, F'14) consulting engineer, vice-president of the Institute 1906–8, and a pioneer in hydroelectric and transmission developments on the Pacific Coast, died at Redding, California, his place of residence, March 14, 1932. He was 61 years of age. Mr. Baum was born at Ste. Genevieve, Missouri; his batchelors degree in electrical engineering was conferred upon him by Stanford University at the time of his graduation in 1898. In 1899 he received his E.E. degree at the completion of a year spent at the same institution as assistant in electrical engineering. To bring the consumer and producer together is a most interesting economic problem of any age, and this was the work which Mr. Baum made the keynote of his remarkable career. He was employed first by the Standard Electric Company of California. Blessed with high inventive genius, he was enabled to solve many problems in the production and transmission of power. In the Piedmont station (Calif.) he was the originator of the compounding of synchronous motor-generator sets, whereby the compounding of the exciters was taken from the shunt on the busbar of the railway load, changing the power factor of the motors and keeping the potential of the substation nearly normal. This was in line with his much later invention, the synchronizing condenser and regulator, announced in 1927, a device which solved the problem of economical transmission of large amounts of electrical power over distances of several hundred miles, dividing the lines into sections of from 100 to 200 miles linked by rotary regulators or condensers, each transmitting the current onward with small losses. W. S. Rugg (A'02, M'13) vice-president of the Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa., by which the patents were acquired is quoted as asserting that "by means of it the capacity of a given line can be increased 75 per cent at a cost not exceeding 20 per cent of the original cost of the line, making possible the economical transmission of power from distant waterfalls and ultimately making possible for sparsely settled outlying districts and farms almost anywhere in the United States a supply of electric power." From 1900 to 1902 he was instructor in electrical engineering at Stanford University at the same time doing special work in electrical transmission for the Bay Counties Power Company and others. He then became an electrical engineer of the California Gas and Electric Corporation, and from 1907 on practised consulting engineering with special reference to hydroelectric developments. The conception and much of the engineering outline of the Pit River power developments for the Pacific Gas and Electric Company were attributable to Mr. Baum's foresight and appreciation of possibilities. He designed Hat Creek Nos. 1 and 2, Pit River No. 1, the 220,000-volt Pit transmission line, and the great Vaca substation at the receiving end. His work during the years 1926–8 was developing insulators and regulations systems outlined in his paper "Voltage Regulations and Insulation of Large-power Long-Distance Transmission System" for which he received the Institute's 1921 yearly transmission prize. For the betterment of social conditions Mr. Baum believed firmly in the linking of business enterprise with scientific thinking, his expressed thought being that "the best control of a utility is that which develops an eagerness and ability on the part of the company to furnish service and an equal eagerness and ability on the part of the consumer to purchase the service. He was the author of the books "Alternating Current Transformer" and "Atlas of U. S. A. Electric Power Industry." Several years were spent studying the European electrical power industry, and he completed a voluminous report on the enlargement and extension of one of Germany's largest electric utilities. His international reputation took him into both France and Germany as a consultant for power concerns, and upon his return to California he established extensive laboratories in the mountains of the northern part of the state for a further study of electrical engineering.

Engelhardt Wilboren Holst (A'05) consulting engineer with offices in Boston, Mass., died at his home in Concord, N. H., February 1, 1932. He was 61 years of age. A native of Christiania, Norway, Mr. Holst received his early technical training there, graduating with an M.E. degree. He came to the United States and engaged with the General Electric Company of Chicago in the summer of 1895, starting with the General Electric test course and subsequently being promoted to the superintendency of the company's repair shop. Two and a half years were spent with the company's Canadian office and one year in travel. In 1905 he took the position of superintendent of equipment for the B & N and Old Colony Street Railway Company, Boston, Mass., and later assumed like duties with the Bay State Railway Company, also of Boston. The Boston consulting engineering practise in which he was engaged at the time of his death was established in 1920.

Isabelle Conkling Conlin (nee Williams) (A'21) of Hempstead, N. Y., died January 23, 1932; she had been ill for several years. Born in Brooklyn April 6, 1894, Mrs. Conlin received her early education in the New York public schools. In 1917 she was graduated from Barnard College, the Columbia University School for women in New York City. She immediately became associated with the Western Electric Company as engineering assistant in the physical laboratory and in 1920 was made laboratory engineer supervising an electrical measurement group, and establishing for herself a creditable record of achievement and capability.

Jeremiah Joseph Kennedy (A'00, M'02) consulting engineer, Brooklyn, N. Y., died February 15, 1932. He was born in Philadelphia, Pa., October 22, 1864, and was educated in the private schools of that city. His technical education also was obtained under private tutelage and included chemistry, and civil, mechanical, and electrical engineering, this last subject receiving the major part of his attention. The first of the year 1882 he joined the Norfolk and Western railroad as a rodman, returning in the fall of that year to study higher mathematics and civil engineering.

The following June he became principal assistant to General Russell Thayer, in civil engineering; for another year, still pursuing his studies, he spent considerable time visiting mines, various works in operation, and inspecting important structures. July 1885, he was given charge of various field surveys in Pennsylvania and Virginia, and in August became chief engineer of the Lynchburg Iron Company operating iron mines and constructing railroads. During the major part of 1886 he served as principal assistant to General Russell Thayer, but in November 1888, he turned his attention to electrical engineering and six years later became principal assistant engineer to J. G. White, president of J. G. White & Company of New York and Baltimore; three years later he was made chief engineer. With this company his work included cable and electric railway construction; the design and construction of subways in Baltimore; design, construction, and operation of electric light and power plants; the design and construction of substations for the Toledo and Detroit railway, and for the Niagara Falls-Buffalo transmission line. Previous to this he was for two years chief engineer of Atlantic Highlands, Red Bank, and Long Branch Electric Railway and for over a year he filled the position of chief engineer and superintendent of the Borough of Manhattan Electric Company, New York City, for the purpose of reconstructing and reorganizing its plants, and subsequently to plan and install extensions; it was while filling these positions Mr. Kennedy secured his permanent position as chief engineer of the J. G. White and Company. Mr. Kennedy was one of the first engineers to appreciate the advisability of making parts and flywheels of engines used in parallel operation of such weight that they would have no tendency to vibrate in harmony with the electrical oscillations. His attack of any engineering problem was energetic and intelligent and he was an enthusiastic and indefatigable worker. Among his other achievements in the line of electrical design and construction were the Detroit and Lake Orion Railway, Detroit, Mich., the power station at Perth, West Australia, and the design of a proposed central station for the Third Avenue railway of New York City.

Local Meetings

Past Section Meetings

Atlanta

Audible Light, by John B. Taylor, Genl. Elec. Co. Demonstrations. Feb. 15. Att. 850.

Chicago

Electric Motor Control, by G. C. Wilms, Bradley Mfg. Co. Joint meeting with Western Soc. of Engrs. Feb. 15. Att. 178.

Cincinnati

Electric Shock, by Dr. W. B. Kouwenhoven, Johns Hopkins Univ., vice-pres. A.I.E.E. Dinner. Feb. 25. Att. 85.

Cleveland

Demonstration and lecture by S. P. Grace, asst. vice-pres., Bell Telephone Labs., Inc. Joint meeting with Advertising Club, Chamber of Commerce, Cleveland Engg. Soc., and Elec. League. Feb. 3–4. Att. 5,000.

Field Studies of Lightning Protection on Distribution Circuits, by K. B. McEachron, Genl. Elec. Co. Feb. 18. Att. 107.

Dallas

The Electrical Industry of Today, by Dr. C. E. Skinner, pres. A.I.E.E., asst. director of engg., Westinghouse Elec. & Mfg. Co. Feb. 26. Att. 127.

Construction Progress at the Hoover Dam, by S. O. Harper, U.S. Bureau of Reclamation. Demonstrations. Dinner. Feb. 10. Att. 60.

Detroit-Ann Arbor

Fundamental Physical and Psychological Aspects of Television, by J. O. Perrine, Am. Tel. & Tel. Co. Demonstrations. Joint meeting with Detroit Engg. Soc. Feb. 16. Att. 650.

Erie

History and Development of Motor Driven Electric Clocks, by Alvan Fisher, Warren Telechron Co. Feb. 16. Att. 100.

Fort Wayne

Radio Interference, by Arthur B. Smith, Assoc. Elec. Labs. Discussion. Feb. 11. Att. 90.

Houston

The Electrical Industry of Today, by Dr. C. E. Skinner, pres. A.I.E.E., asst. director of engg., Westinghouse Elec. & Mfg. Co. Dinner. Feb. 24. Att. 85.

Indianapolis-Lafayette

Electrons at Work and at Play, by Dr. Phillips Thomas, Westinghouse Elec. & Mfg. Co. Demonstrations. Feb. 10. Att. 340.

Ithaca

Protection of Distribution Circuits and Apparatus, by B. B. McEachron, Genl. Elec. Co. Feb. 19. Att. 124.

Kansas City

Light and Architecture, by A. L. Powell, Genl. Elec. Co. Dec. 28. Att. 110.

Control of Smoke Nuisance in Cities, by A. S. Longsdorf, Wash. Univ. Joint meeting with A.S.M.E. Sec. Jan. 15. Att. 85.

Los Angeles

Overseas Telephone Services of the Bell System, by W. H. Harrison, Am. Tel. & Tel. Co. Demonstrations. Feb. 9. Att. 106.

Louisville

Lightning—Recent Investigations and Findings, by F. W. Peek, Jr., Genl. Elec. Co. Demonstrations. Feb. 19. Att. 169.

Lynn

America Steps Ahead With the Akron, by R. H. Smith, M.I.T. Movies. Feb. 10. Att. 1,054.

Mercury Vapor Turbines, by L. A. Sheldom and B. P. Coulson, Genl. Elec. Co. Feb. 24. Att. 500.

Memphis

Development of Vocational Guidance, by J. L. Highsaw, Memphis Tech. High Sch. Feb. 9. Att. 35.

Mexico

Some Recent Developments and Trends in Electrical Machinery and Apparatus, by Dr. C. E. Skinner, pres. A.I.E.E., asst. director of engg., Westinghouse Elec. & Mfg. Co. Demonstrations. Feb. 17. Att. 70.

Banquet. Feb. 18. Att. 58.

Minnesota

Research Work in Laboratory Developments, by H. D. Sanborn, Genl. Elec. Co.; The Challenge to the American Business Man, by J. B. Chapple, Ashland Daily Press. These talks were given before the convention of the Minnesota Federation of Architectural and Engg. Societies. Feb. 26–7. Att. 100.

Montana

Recent Developments in the Electrical Field, by A. D. Atewart, Westinghouse Elec. & Mfg. Co. Discussion. Feb. 18. Att. 43.

Dean H. V. Carpenter, State Col. of Wash., vice-pres. A.I.E.E., gave a report of the winter convention held in New York. Discussion. Feb. 25. Att. 20.

New York

Marine Engineering and the American Merchant Marine, by Arthur M. Tode, pres., Propeller Clubs of the U.S. (Transportation group.) Feb. 10. Att. 275.

Characteristics and Protection Requirements of the Low-Voltage A.C. Network, by C. W. Pickells, N. Y., and Queens Elec. Lt. & Pwr. Co., A. Pinto, Otis Elevator Co., L. A. Nettleton, Bklyn. Edison Co. (Power Group.) Feb. 18. Att. 250.

The New Music of Electrical Oscillations, by Benjamin Miessner, Capt. Richard Ranger, and Prof. Leon Theremin. Feb. 26. Att. 875.

Recent Investigations of New York City Smoke, by E. E. Free, N. Y. Univ. March 8. Att. 75.

Oklahoma City

Noise Induction Between Power Transmission and Telephone Circuits, by E. B. Jennings, Southwestern Bell Tel. Co., and C. E. Bathe, Oklahoma Gas & Elec. Co. Demonstrations. Jan. 25. Att. 115.

Philadelphia

Electron Tubes in Industry, by E. H. Alexander, Genl. Elec. Co. Demonstrations. Jan. 11. Att. 150.

Shif Stabilization by Electrically Controlled Mechanical Devices, by Nicholas Minorsky, Univ. of Pa. Feb. 8. Att. 180.

Pittsburgh

The Westinghouse Section Mercury Arc Rectifier, by A. L. Atherton, J. H. Cox, D. C. West, H. Speight, A. J. Maslin, R. R. Longwell, and J. Slepian. Joint meeting with Engrs. Soc. of Western Pa., Feb. 9. Att. 453.

An Outdoor Mercury Boiler Power Station, by A. R. Smith, Genl. Elec. Co. Dinner. Joint meeting with Engrs. Soc. of Western Pa., March 8. Att. 174.

Pittsfield

Men Made Island to Speed Ocean Flying, by E. R. Armstrong, Armstrong Seadrome Corp. Feb. 16. Att. 300.

Famous Women Spies and Their Methods, by Maj. Thomas Coulson. Dinner. March 1. Att. 1,450.

Portland

Motion pictures describing cable manufacture and short talks on telephone transmission. Feb. 23. Att. 75.

St. Louis

The World of Electrons, by Larry Hawkins, Genl. Elec. Co. Feb. 16. Att. 1,600.

San Antonio

The Electrical Industry of Today, by Dr. C. E. Skinner, pres. A.I.E.E., asst. director of engg., Westinghouse Elec. & Mfg. Co. Feb. 23. Att. 99.

San Francisco

Overseas Radio Telephone Servce of the Bell System, by W. H. Harrison, Am. Tel & Tel. Co. Joint meeting with I.R.E. and Signal Corps Assn. Feb. 12. Att. 450.

Schenectady

Vertical Transportation in Buildings, by

Bassett Jones, Meyer, Strong, and Jones. Joint meeting with A.S.M.E. Jan. 21. Att. 125.

AIR CONDITIONING IN BUILDINGS, by A. R. Stevenson, Gen. Elec. Co. Joint meeting with A.S.M.E. Sec. Feb. 4. Att. 130.

THE GREAT ICE AGE IN NORTH AMERICA, by K. F. Mather, Harvard Univ. Joint meeting with A.S.M.E. Sec. Feb. 18. Att. 425.

Seattle

SEGREGATION OF HYDROELECTRIC POWER COSTS, by W. S. McCrea, Jr.; GENERATOR VOLTAGE REGULATORS, by K. L. Howe; REFLECTED VOLTAGE WAVES IN SINGLE PHASE INDUCTION MOTORS, by D. C. Moore; RESIDENTIAL UNDERGROUND DISTRIBUTION SYSTEM, by Wallace Quistorff. W. S. McCrea awarded prize of $25 for presentation of best paper. Jan. 19. Att. 75.

Sharon

MODERN MARVELS, by C. K. Lee, Westinghouse Elec. & Mfg. Co. Feb. 16. Att. 135.

Spokane

INSTITUTE AFFAIRS AND REPORT ON THE WINTER CONVENTION, by Dean H. V. Carpenter, State Col. of Wash., vice-pres., A.I.E.E. Feb. 26. Att. 21.

Toledo

Executive committee meeting. Feb. 9. Att. 9.

PROTECTIVE RELAYS, by J. H. Hunt, Toledo Edison Co.; MODERN CIRCUIT INTERRUPTERS, by J. Slepian, Westinghouse Elec. & Mfg. Co. Demonstrations. Discussion. Feb. 19. Att. 80.

Toronto

NON-RESONATING TRANSFORMERS, by K. K. Palueff, Genl. Elec. Co. Demonstrations. Feb. 11. Att. 114.

AUTOMATIC FREQUENCY CONTROL, by J. B. McClure, Genl. Elec. Co. Joint meeting with Niagara Frontier Sec. and Engg. Inst. of Canada. Feb. 19. Att. 151.

SOME PHYSICAL CHARACTERISTICS OF SPEECH AND MUSIC, by Harvey Fletcher, Bell Tel. Labs., Inc. Demonstrations. Feb. 26. Att. 350.

Urbana

MODERN HIGH POWER TRANSMISSION ANTENNA, by Prof. H. A. Brown, Univ. of Ill. March 2. Att. 35.

Utah

WHAT MEN SEE WITH, by A. S. Bennion, Utah Pwr. & Lt. Co. Dinner. Feb. 8. Att. 70.

Washington

SOME THOUGHTS ON WAVES, by O. B. Blackwell, Am. Tel & Tel. Co. Dinner. Feb. 9. Att. 130.

Future Section Meetings

Akron

April 12—THE ELECTRICAL INDUSTRY AND SOME PROBLEMS OF THE INSTITUTE, by Dr. C. E. Skinner, pres. A.I.E.E., asst. director of engg., Westinghouse Elec. & Mfg. Co. Movies.

May 10—Annual banquet and ladies' night. HUMAN ENGINEERING, by Dean Fred E. Ayer, Univ. of Akron. Movies.

Baltimore

April 15—Subject to be announced. Speakers from Western Electric Co.

May 20—Speaker: Dr. W. B. Kouwenhoven, Johns Hopkins Univ., vice-pres. A.I.E.E.

Cleveland

April 21—ELECTRIC REFRIGERATION AND DOMESTIC AIR CONDITIONING, by W. M. Timmerman, Genl. Elec. Co.

May 19—Subject and speaker to be announced.

Dallas

April 11—THE COORDINATION OF LINE AND STATION DESIGN FOR LIGHTNING SURGE CONDITIONS, by A. O. Austin, Ohio Brass Co.

Detroit-Ann Arbor

April 19—COMMERCIAL METERING OF ELECTRIC ENERGY, by A. S. Albright, Detroit Edison Co.

May 17—HOUSE OF MAGIC, by Oliver Ajer, Genl. Elec. Co.

Louisville

April 15—Inspection trip to Bowman Field Airport. FUNDAMENTALS OF PLANE CONSTRUCTION AND FLIGHT, by A. W. Lee, Louisville Gas & Elec. Co.

May 13—DIAL TELEPHONE EQUIPMENT IN LOUISVILLE. Speaker from Southern Bell Tel. & Tel. Co.

New York

April 15—Final meeting of power group; general subject: regulation of power flow between interconnected systems. GENERAL PROBLEMS OF INTERCONNECTION, H. L. Melvin, Electric Bond and Share Company; AUTOMATIC CONTROL OF FREQUENCY AND LOAD, J. B. McClure, Genl. Elec. Co. Election of power group officers. Meeting to be held in Engineering Societies Building at 7:30 p.m.

Pittsburgh

April 12—TELEVISION. Demonstrations. Joint meeting with I.R.E.

May 10—Annual banquet and ladies' night.

Seattle

April 19—Joint meeting with Student Branch at Univ. of Wash.

May 17—Address by L. Sapovi, Hooker Electro-Chemical Co.

Spokane

April 22—NEW DEVELOPMENTS IN OIL CIRCUIT BREAKERS, by J. F. Spease, Genl. Elec. Co.

May 27—Annual dinner meeting. HISTORY OF THE ELECTRICAL DEVELOPMENT OF THE INLAND EMPIRE, by John B. Fisken. Election of officers.

Toledo

April 15—PROBLEMS IN THE DESIGN OF LARGE TURBO-ALTERNATORS, by S. H. Mortensen, Allis-Chalmers Co.; APPLICATION OF ELECTRICITY IN INDUSTRY, by R. E. Paxton, Toledo Edison Co.

Vancouver

April 4—SWITCHGEAR, by W. D. Robertson, Canadian Genl. Elec. Co., Ltd.

May 2—Open.

May 21—Annual outing to the Baker River Plant of the Puget Sound Pwr. & Lt. Co.

Past Branch Meetings

University of Akron

BIOGRAPHY OF ALEXANDER GRAHAM BELL, by R. I. Felver, student; BAFFLE BOARDS AND THEIR RELATION TO MODERN LOUDSPEAKERS, by Sol. Leibowitz, student. Demonstrations. Feb. 24. Att. 9.

Alabama Polytechnic Institute

ELECTRIFICATION OF THE NORFOLK AND WESTERN RAILWAY, by F. N. Williams, student; TELEPHONE SYSTEMS, by D. P. Johnson, student. Feb. 18. Att. 10.

MANUFACTURE OF CAST IRON PIPE BY THE MONO-CAST CENTRIFUGAL PROCESS, by S. D. Moxley, Am. Cast Iron Pipe Co. Joint meeting with A.S.M.E. Feb. 2. Att. 45.

University of Arkansas

NON SINE WAVES, by H. G. Thomasson, student; VECTORS, by E. E. Ray, student; HARMONIC ANALIZERS, by J. G. Lewis, student. Feb. 3. Att. 35.

ELECTRIC SHOVELS, by Robert Vining, student; BRUSHES, by E. E. Boreland, student; AUTOMATIC STOPS FOR ELEVATORS, by F. L. McDonald, student. Feb. 15. Att. 30.

Armour Institute of Technology

BUILDING NETWORKS, by E. E. Chilberg, Genl. Elec. Co. Feb. 19. Att. 30.

University of British Columbia

AUTOMATIC TELEPHONY, by J. W. McRae, student. Discussion of transmission systems. Feb. 9. Att. 14.

THE C.G.E. TEST COURSE, by S. D. Scott, student; THE AUTOMATIC SWITCHBOARD INSTALLED FOR THE POWELL RIVER PULP AND PAPER CO., by H. E. Woodland, student. Film—"The Transportation Problem." Feb. 23. Att. 19.

Film—"Electrification of the Mexicana Railway." Feb. 24. Att. 100.

Brooklyn Polytechnic Institute

THE PIANOFORTE OR ENGINEERING APPLIED TO THE ART OF MUSIC, by Wm. B. White, Am. Steel & Wire Co. Demonstrations. Refreshments. Jan. 14. Att. 200.

Bucknell University

LIGHTING AND ITS RELATION TO INDUSTRIES, by George Heinish, student. Feb. 11. Att. 12.

University of California

THE DEVELOPMENT AND APPLICATION OF VACUUM TUBES, by A. W. Copley, Westinghouse Elec. & Mfg. Co., vice-pres. A.I.E.E. Banquet. Feb. 19. Att. 46.

ENGINEERING OBSERVATIONS ON A RECENT TRIP EAST, by W. C. Smith, Genl. Elec. Co. Feb. 24. Att. 35.

Case School of Applied Science

THE RESEARCH ATTITUDE, by Prof. T. D. Owens; SAFETY DEVICES ON STREET CARS, by J. C. Elder, student; X-RAY PROTECTIVE DEVICES, by W. J. Cherney, student. Feb. 17. Att. 51.

W. J. Cherney elected chairman. March 4. Att. 43.

Catholic University of America

ELECTRICITY AND THE TELEPHONE, by Mr. Gioffre, Chesapeake & Potomac Tel. Co. Refreshments. Feb. 24. Att. 3.

University of Cincinnati

ELEVATOR MOTORS AND CONTROL, by A. J. Liebenberg, Warner Elev. Co. Feb. 17. Att. 40.

Clemson Agricultural College

PHOTOELECTRIC TUBES, by Prof. F. T. Tingley; THE PRESENT PRACTISES IN INSULATED POWER CABLES, by W. G. Wallenberg, student. March 3. Att. 20.

University of Colorado

Films—"Speeding up Our Deep Sea Cables" and "Pictures by Wire." Refreshments. Feb. 10. Att. 55.

NEW IDEAS FOR HIGH VOLTAGE CIRCUIT BREAKERS, by C. A. Church and N. R. Damon. Slides. Feb. 24. Att. 30.

Cooper Union

ENGINEERING ASPECTS OF THE SOVIET FIVE YEAR PLAN, by W. N. Polakov. Feb. 4. Att. 70.

University of Denver

Films—"Mazda Lamps," "Electric Ships," "Liquid Air," and "A Visit to the General Electric Factory With Earl Carroll." Feb. 18. Att. 84.

University of Detroit

CONSTRUCTION AND APPLICATION OF STORAGE BATTERIES, by W. C. Leingang, Elec. Stor. Bat. Co. Film—"The Electric Ship." March 2. Att. 45.

Duke University

MERCURY ARC RECTIFIERS, by Mr. Creekmore, student. Discussion. Feb. 11. Att. 13.

ILLUMINATION AND NEON TUBES, by Mr. Garrett, student; SHORT WAVE RECEIVING CIRCUITS, by Mr. Flack, student. Feb. 25. Att. 13.

University of Florida

AMATEUR RADIO, by G. W. Haug, student; THE KENNELLY-HEAVISIDE LAYER AND METHODS FOR DETERMINING ITS HEIGHT, by D. G. Beck. March 7. Att. 25.

Georgia School of Technology

Films—"Automatic Arc Welding" and "Busy Body." Feb. 16. Att. 60.

University of Illinois

Discussion of plans for the elec. engg. show. Feb. 17. Att. 100.

Iowa State College

Film—"The Life of Edison." Feb. 10. Att. 50.

University of Iowa

Films—"General Electrical Icing Unit." Election of officers as follows: H. A. Peterson, chmn.; L. E. Travis, vice-chmn.; J. F. Kapinos, secy-treas. Feb. 3. Att. 44.

Discussion. Feb. 10. Att. 44.

ELECTRICAL RELAYS, by M. J. Larsen, student. Feb. 17. Att. 30.

NEW RADIO AIR CELL A BATTERY, by L. F. Grizel, student; THE GROWTH OF THE UNIVERSITY RADIO STATION, by R. E. Griffin, student; ELECTRICITY IN THE MOFFAT TUNNEL, by D. G. Fritz, student; TELEVISION, by E. C. Dunn, student. Feb. 24. Att. 38.

Kansas State College

Election of officers. Feb. 4.

Talk by G. W. Wood, Frigidaire Co. Feb. 18. (Afternoon meeting.)

RUSSIA, by J. C. Bradley. Feb. 18. (Evening meeting.)

University of Kansas

COOPERATIVE EDUCATION, by Prof. D. C. Jackson, Jr., counselor. Feb. 18. Att. 36.

THE MAKING OF A LIFE, by R. A. Schwegler, dean, school of education. Films—"Far Speaking" and "Voices Across the Sea." March 3. Att. 54.

Lafayette College

WELDING, by A. S. Cumberland, Ingersoll-Rand Co. Illus. Joint meeting with A.S.M.E. and A.S.C.E. branches. Feb. 26. Att. 50.

Louisiana State Univeristy

THE WYMAN DAM HYDROELECTRIC PROJECT, by E. E. Frenzel, student. Feb. 18. Att. 19.

University of Louisville

ADVANTAGES OF GOVERNMENTAL CONTROL, by J. Groves, student; ADVANTAGES OF PRIVATE OWNERSHIP, by J. Morris, student. Feb. 12. Att. 11.

University of Maine

PLANNING A POWER SYSTEM, by H. W. Coffin, Bangor Hydroelec. Co. Feb. 25. Att. 23.

Marquette University

MAGNETIC TESTING, by Prof J. F. H. Douglas, assisted by Messrs. Trimborn, Dernbach, Hallbach, and Van Peterson, students. Feb. 4. Att. 20.

Massachusetts Institute of Technology

Inspection trip through the L Street generating station of the Edison Elec. Ill. Co. Feb. 19. Att. 15.

THE THYRATRON TUBE, by H. M. Wagner, student. Dinner. Feb. 25. Att. 65.

Michigan College of Mining and Technology

INDUSTRIAL APPLICATIONS OF VACUUM TUBES, by R. E. Welton, Gen. Elec. Co. Films "Automatic Substation for Mining and Industrial Service" and "Big Deeds." Feb. 11. Att. 36.

Michigan State College

THE DEVELOPMENT OF THE VACUUM TUBE, by W. A. Stelzer, student. Feb. 23. Att. 11.

METHODS OF FIXING LIGHT AND POWER RATES, by Mr. Carolyn, Consumers Pwr. Co. March 8. Att. 14.

School of Engineering of Milwaukee

ORGANIZATION, PURPOSE, DUTIES, AND OPERATION OF THE MILWAUKEE FIRE DEPARTMENT, by Mr. Lippold, asst. fire cf. Feb. 10. Att. 46.

University of Minnesota

Inspection trip through the Elec. Mchy. Mfg. Co. Feb. 18. Att. 65.

University of Missouri

ULTRA HIGH FREQUENCY OSCILLATIONS, by C. Thorne and L. Smarr, students; TELEVISION, by H. Leibovich and L. Buell, students. Feb. 17. Att. 18.

ADVENTURES IN SCIENCE, by L. A. Hawkins, Genl. Elec. Co. Joint meeting with Sigma Xi. Feb. 27. Att. 263.

Montana State College

THE SWOPE PLAN, by A. J. Hill, student; A MODERN LAUNDRY, by C. G. Anderson, student; ELECTRIC ARC WELDING IN MINES, by E. Hughes, student; DEVELOPMENT OF TRANSFORMERS, by R. MacDonald; THE ORIGIN OF THE ELECTRICAL SCIENCE, by Wm. H. Scheele. Jan. 28. Att. 103.

University of Nebraska

Film—"Power Transformers." Feb. 17. Att. 22.

Demonstration of thyratron tubes by L. W. Cook and P. Ehrenhard, students. March 2. Att. 34.

Newark College of Engineering

PHOTOELECTRIC CELLS, by J. Wier, student; APPLICATION OF PHOTOELECTRIC CELLS, by W. Amon, student; THYRATRON INVERTER, by W. R. McLaughlin, student. Feb. 29. Att. 22.

University of New Hampshire

Film—"Something About Switchboards." Jan. 9. Att. 28.

A NEW WARNING BEACON WHICH UTILIZES THE VACUUM TUBE, by A. Philbrick, student; CONVICT LABOR IN HIGHWAY CONSTRUCTION, by H. W. Feindel, student. Jan. 16. Att. 27.

THE SOLUTION OF UNBALANCED FAULTS ON TRANSMISSION LINES BY THE METHOD OF SYMMETRICAL COORDINATES, by H. R. Stewart, Westinghouse Elec. & Mfg. Co. Jan. 20. Att. 78.

Discussion. Feb. 6. Att. 24.

THE FUTURE ENGINEER, by O. K. Reid, student; THE ELECTRON TUBE IN INDUSTRY, by H. W. Hunt, student. Feb. 13. Att. 21.

Discussion of plans for spring inspection trip. Feb. 20. Att. 22.

Discussion. Feb. 27. Att. 26.

PREDETERMINED COUNTER AND ITS USES, by J. Prentice, student; DIESEL ELECTRIC DRIVES USED ON TRAMP STEAMERS, by R. D. Ives, student. March 5. Att. 21.

University of New Mexico

Discussion of plans for engineers' day. Feb. 17. Att 10.

ENGINEERING ACHIEVEMENTS OF THE GENERAL ELECTRIC CO. DURING 1931, by Martin Zirhut, student. Feb. 25. Att. 17.

College of the City of New York

Discussion. Feb. 18. Att. 18.

THE TOOLS OF MODERN WARFARE, by Maj. Carl de Zafra, U.S. Army. Feb. 25. Att. 44.

SOME RECENT DEVELOPMENTS IN ELECTRICAL COMMUNICATION, by R. D. Parker, Am. Tel. & Tel. Co. Demonstrated. March 3. Att. 40.

New York University

QUASI OPTICAL WAVES, by E. H. Osterland, student; LABOR UNIONS, by W. Rubsamen, student. Feb. 16. Att. 12.

AMATEUR RADIO STATION EQUIPMENT, by J. Mantone, student; MEASUREMENT OF THE MOISTURE CONTENT OF WOOD BY ELECTRICAL METHODS, by A. W. Lebert, student. Feb. 23. Att. 13.

THE PRESENT PATENT SITUATION, by L. C. Dinnar, student; QUARTZ CRYSTAL OSCILLATORS, by H. C. Fleming, student. March 1. Att. 13.

THE DEVELOPMENT OF THE USE OF ELECTRICITY AT SEA, by J. P. Munroe, student; THE INDUCTIVE COMPENSATING GENERATOR, by C. J. Dunn, student. March 8. Att. 13.

North Carolina State College

NEON TUBES, by K. L. Ponzer, student; LATE ELECTRICAL DEVELOPMENTS, by C. M. Smith, student; AMATEUR RADIO TRANSMISSION AND RECEPTION, by D. A. Worsley, student; ELECTRICITY IN SYRIA, by Joseph Salem, student. Jan. 26. Att. 31.

Film—"General Electric Enameling Furnace." Feb. 9. Att. 21.

North Dakota State College

RECENT DEVELOPMENTS IN MODERN ILLUMINATION, by O. P. Cleaver, Westinghouse Elec. & Mfg. Co. Feb. 5. Att. 93.

IMPRESSIONS OF ENGINEERING, by Foster Buck. Film "The Story of the Glass Bottle." Joint meeting with A.S.M.E. and A.S.C.E. branches. Feb. 18. Att. 66.

University of North Dakota

ENGINEERING DEVELOPMENTS IN 1931, by L. A. Myrand, Westinghouse Elec. & Mfg. Co. Film—"Dynamic America." Feb. 17. Att. 32.

TELEVISION, by O. A. Bondeled, North Western Bell Tel. Co. March 2. Att. 28.

Northeastern University

THE CATHODE RAY OSCILLOGRAPH, by H. W. Samson, Genl. Radio Co. Demonstrations. Feb. 17. Att. 82.

University of Notre Dame

MOTOR CONTROL, by C. J. Maloney, Cutler Hammer Mfg. Co. Demonstrations. INCIDENTS IN THE DEVELOPMENT OF ELECTRIC TRACTION, by P. McCaffrey, student. John Scanlan, student, presented the new reviews. Feb. 15. Att. 77.

MANUFACTURE OF A RADIO TUBE, by W. S. Brian, Grigsby-Grunow Co.; DEVELOPMENT OF THE INCANDESCENT LAMP, by C. Roberts, student; SOUND ON FILAMENT, by L. Simmons, student; ENGINEERING CULTURE, by H. E. Ball, student. John Scanlan, student, presented the usual current review. Feb. 29. Att. 71.

Ohio Northern University

A.C. WELDING, CONCEPTION OF THE ELECTRON THEORY, and METHODS OF LOCATING GROUNDS ON POWER LINES, by O. R. Jacobs, student. Jan. 14. Att. 19.

HOME LIGHTING, by L. Berger, student. Demonstrations. Jan. 28. Att. 9.

Ohio University

FILM—"From Mine to Consumer." H. B. McCrone, Am. Brass Co., explained the film. Feb. 17. Att. 55.

EDISON THREE WIRE TRANSMISSION LINES, by R. H. Lloyd, student. March 9. Att. 13.

Oregon State College

LIFE OF EDISON, by B. Blazen, student. SHORT WAVE RADIO TRANSMISSION TO HAWAII, by R. W. Deardork, Pac. Tel. & Tel Co. Demonstrations. Feb. 11. Att. 57.

Pennsylvania State College

THE RECENT TUBE DEVELOPMENTS OF INTEREST TO INDUSTRY, by H. L. Saxton. Feb. 19. Att. 75.

University of Pittsburgh

ELECTRIFICATION OF RAILROADS, by C. E. Coleman, student; LIFE OF FARADAY, by W. Piercy, student. Jan. 14. Att. 128.

OPERATION OF AUTOMATIC TRAIN SIGNALING, by H. E. Kallenburger, Union Switch and Signal Co. Demonstrations. Jan. 19. Att. 87.

INDUSTRIAL APPLICATION OF VACUUM TUBES, by R. Hansen, student. Feb. 4. Att. 127.

CODE SYSTEM OF CONTINUOUS TRAIN CONTROL, by O. L. Zimmerman, student; METHODS OF ROLLING STEEL PLATES, by M. Zofchak, student. Feb. 11. Att. 120.

PHOTOELECTRIC CELLS, by Wm. Dambart, student. Feb. 18. Att. 126.

MERCURY ARC RECTIFIERS, by Mr. Atherton, Westinghouse Elec. & Mfg. Co. Feb. 25. Att. 126.

Pratt Institute

Film—"Manufacture of Electric Cables." Feb. 4. Att. 25.

ELECTRICITY AND THE PIPE ORGAN, by D. Enslee, student. Feb. 17. Att. 20.

Princeton University

Film—"Electrical Measuring Instruments." Feb. 11. Att. 8.

Purdue Univ.

EINSTEIN'S THEORY, by R. J. Kryter, Prest-O-Lite Stor. Bat. Co. Feb. 16. Att. 508.

Rhode Island State College

TELEVISION, by Messrs. Daly and Downes, students. Feb. 25. Att. 12.

Rice Institute

Election of Officers as follows: E. A. Turner, Jr., chairman; G. R. Adams, vice-chairman; J. E. Reed, secy.; R. C. Bearmann, treas. Feb. 17. Att. 11.

Rose Polytechnic Institute

HISTORY AND MANUFACTURE OF CABLES, by F. E. Calvert, Gen. Elec. Co. March 3. Att. 36.

Rutgers University

THE TWIN FUNCTION OF ENGINEERING, by J. Rudnitsky, student. Feb. 16. Att. 17.

SWEEP CIRCUITS OF CATHODE RAY OSCILLOSCOPE, by B. Schmurak, student. Feb. 23. Att. 20.

University of South Carolina

TELEVISION SCANNING BY MEANS OF CATHODE RAY TUBES, by R. M. Warren, Jr., student; UNLOADING OF GRAIN CARS, by J. T. Lyman, student; DIAL TYPE THERMOTEL, by E. C. Willis, student. March 10. Att. 55.

South Dakota State School of Mines

COMBUSTION, by Chuck Laws, Montana-Dakota Pwr. Co. Feb. 25. Att. 28.

University of South Dakota

Film—"The Single Ridge." Feb. 16. Att. 35

University of Southern California

Discussion. Feb. 3. Att. 15.

Discussion and moving pictures. Feb. 10. Att. 31.

Southern Methodist University

UNDERGROUND DISTRIBUTION NETWORK SYSTEM OF DALLAS POWER & LIGHT CO., by M. M. Lehmberg, student. Feb. 16. Att. 12.

Luncheon. Feb. 24. Att. 11.

Stanford University

RADIO BROADCASTING STATION AT SANFORD AND ITS EQUIPMENT, by P. F. Byrne, student; HIGH VOLTAGE TRANSMISSION, by Prof. J. S. Carroll, counselor. Jan. 14. Att. 28.

Inspection trip through the studios of the Natl. Broadcasting Co., Inc. Jan. 30. Att. 40.

Television, by A. H. Brolley, Television Labs. Feb. 4. Att. 68.

Design of the Portable Motor Generator Set Which Was Used by the Byrd Antarctic Expedition, by Mr. Heintz, Heintz and Kaufman. Joint meeting with A.S.M.E. Branch. Feb. 10. Att. 42.

Stevens Institute of Technology

Personnel Work in the New York Edison Co., by Prof. F. C. Stockwell, counselor. Feb. 5. Att. 38.

The Setting of Clocks by Radio, by Prof. H. C. Roters. Feb. 16. Att. 26.

Syracuse University

The Piezo Electric Effect and Its Utilization, by J. L. Schmieder, Jr., student; History of the Telephone, by Wm. Bangs, student. Feb. 12. Att. 21.

Control Frequency Broadcast, by L. G. Curry, student; Electrolysis of Cast Iron Pipe, by H. Coswell, student. Feb. 19. Att. 21.

The Earth as a Current Conductor, by F. DeBoalt, student. Feb. 26. Att. 21.

A. & M. College of Texas

Some Developments by G.E. in 1931, by W. Clayton, Gen. Elec. Co. Illustrations. Various G.E. Products, by Mr. Alen, Genl. Elec. Co. Feb. 11. Att. 94.

The Electrical Industry of Today, by Dr. C. E. Skinner, pres. A.I.E.E., asst. director of engg., Westinghouse Elec. & Mfg. Co. Feb. 25. Att. 800.

Texas Technological College

Life of Thomas A. Edison, by W. Nott, student. Slides. Feb. 11. Att. 14.

University of Texas

Harmonic Analysis of Distorted Wave Form, by Dr. S. L. Brown. Feb. 11. Att. 12.

University of Utah

The History of Amateur Radio, by L. K. Irvine, student. Discussion. Jan. 28. Att. 37.

Debate: Resolved: That the Engineer Has Caused the Depression. Affirmative—D. Ashby, R. C. Hansen, students. Negative—S. Ramo, R. Kirkman, students. Negative side won. Feb. 25. Att. 36.

University of Vermont

The Effect of Electrode Shape on High Voltage Stresses in Insulators, by Mr. Whitman. Illus. Feb. 15. Att. 19.

Virginia Polytechnic Institute

Light Relays and Light Source Units, by R. W. McCorkle, student; Power Auxiliaries, by H. E. Naylor, student; Active and Inactive Duties of the Advanced R.O.T.C. Student, by M. H. Mills, student; Electric Heating and Wood Block Floor Construction, by C. K. Luck, student. Feb. 11. Att. 47.

Method of Weighing Small Particles, by W. C. McCall, student; Oil Filled Cables, by W. L. Outten, student; The Prerequisites of an Electrical Engineer, by G. R. Snyder, student; High Speed Submarine Cables, by A. I. Osborne, student; New Power Transformers, by T. E. Gilhooley, student; Electrical Operation of Dredges, by A. L. Pond, student. Feb. 18. Att. 54.

Use of Natural Has for Generating Electrical Energy, by J. H. Pharis, student; Three Power Locomotives, by J. E. Hamm, student; Electro-Plating, by A. M. Potts, student; The Economic Phase of Electrified Railroads, by W. C. Cottrell, student. Feb. 25. Att. 54.

The Oscillograph, by H. A. Frazier, student; The Life of Samuel Morse, by R. E. Philbeck, student; Load Ratio Control for Transformers, by C. L. Tune, student; Development of Transcontinental Radio Telephones, by D. H. Smith, student; Dial System Automatic Telephones, by E. L. Rowell, student. March 3. Att. 50.

University of Virginia

The Qualifications of an Electrical Engineer, by R. B. Jones, student; Traffic Operated Traffic Signal, by B. G. Switzer, student; Believe It or Not—Pertaining to Electrical Engineering, by T. J. LoCascio, student. Feb. 12. Att. 26.

Washington State College

Election of officers as follows: Philip Nalder, pres.; T. Torkelson, vice-pres.; Gus H. Bliesner, secy.; H. Brittenham, treas. Jan. 29. Att. 22.

Power Plant Achievements for 1931, by R. Uhlig, student; Electrical Instruments, by Prof. O. E. Osburn, counselor. Feb. 12. Att. 26.

University of Washington

Televox, by W. Blashfield, student. Feb. 4. Att. 11.

Electrical Reflections in Induction Motors, by D. J. Moore, student. Feb. 11. Att. 15.

The Public Utilities Place in the Electrical Industry, by H. A. Gardner, Puget Sound Pwr. & Lt. Co. Feb. 18. Att. 17.

Film—"Conowingo." Feb. 25. Att. 72.

Diablo-Seattle Transmission Line, by C. M. Lubcke, Engg. Dept., City of Seattle. March 5. Att. 27.

West Virginia University

History of Rate Making, by H. Locker; Diesel Engines as Peak Load Units, by L. Palmer; An Interview of Dr. H. C. Rentschler, by P. B. Spangler; Engineering Features of Three Power Locomotives, by E. D. Harris; Remote Reading of Watt Hour Meters, by L. P. Kirwin; Vacuum Tube History, by K. H. DeMoss; The Dynamic Radio Microphone, by P. M. Vannoy; all students. Feb. 9. Att. 31.

Power for an Arctic Elevator, by J. L. Simpson; Automatic Combustion Control, by R. H. Colborn; Measuring High Radio Frequencies, by N. I. Hall; Shocks Due to Electricity, by L. H. Winger; Communication in the Waldorf Astoria, by M. Stewart; Photoelectric Recorder, by W. C. McMillian; Foreign Jobs, by W. C. Sandy; all students. Feb. 16. Att. 31.

Development of the Chinese Electrical Industry, by M. Sprigg; Remote Reading of Watt Hour Meters, by D. C. Kennedy; Electric Heating in Wood Block Floor Construction, by J. E. Wallace; Corona Versus Conductor Surface, by F. O. Brown; Transoceanic Radio Telephone Service, by C. J. McCormick; all students. Feb. 23. Att. 29.

Gas Electric Railway Car, by R. H. Colburn; All Wave Radio Receiver, by N. I. Hall; Electrical Units and Their Application, by C. J. DeLancy; Electricity on the Airship Akron, by L. H. Winger; Reducing Noises From Power Transformers, by W. C. Sandy; all students. March 1. Att. 29.

University of Wisconsin

The Private Life of Michael Faraday, by M. L. Dack, student; Michael Faraday's Experiment, by P. E. Patterson, student; Electrical Researches of Faraday, by J. K. Affanasiey, student. Dec. 10. Att. 47.

Dancing Conductors, by W. A. Kuehlthau, student. Moving pictures. Jan. 19. Att. 64.

Electrical Engineering Only? by Charles Moore, Bell Tel. Labs., Inc. Feb. 11. Att. 76.

University of Wyoming

Electron Theory, by Dr. P. F. Hammond, head, physics dept. Joint meeting with A.S.M.E. Branch. Feb. 23. Att. 17.

Addresses Wanted

A list of members whose mail has been returned by the postal authorities is given below, with the address as it now appears on the Institute records. Any member knowing of corrections to these addresses will kindly communicate them at once to the office of the secretary at 33 West 39th St., New York, N. Y.

Berry, Wayne J., c/o Genl. Elec. Co., Schenectady, N. Y.
Bugg, Vernon, 736 Transportation Bldg., Washington, D. C.
Combs, Clinton R., 13564 Northlawn Ave., Detroit, Mich.
Fay, John L., Genl. Del., Philadelphia, Pa.
King, Milton E., 1521 Laketon Rd., Wilkinsburg, Pa.
Master, J. J., 36–7 Canning St., Calcutta, India.
Miyamoto, Tatsuo C., 1330—4th St., Sacramento, Calif.
Palit, Hari-Charan, 151 Ganesh Mohal, Benares City, India.
Rogge, C. A., Consumers Pwr. Bldg., Jackson, Mich.
Thomas, Earl Mead, Intl. Genl. Elec. Co., Schenectady, N. Y.
Titland, Trygve T., 1019 Stanton Ave., Elizabeth, N. J.
Van Der Dussen, John, 114 Gotham Ave., Gerrittsen Beach, B'klyn, N. Y.

Employment Notes

Of the Engineering Societies Employment Service

Men Available

Construction

DISTRIBUTION ENGR., 29, married, tech. grad. 8 yr. experience in utility field as supt., mgr., engr. foreman, and lineman. One year constructing municipal power and ice plant. Eighteen months elec. installation in large industrial establishment. Available immediately. Location, immaterial. D-442.

ASSOC. E.E., 25, 8 yr. practical experience in elec. construction work on new bldgs., power plants, and alterations. Familiar with all branches of elec. contracting including field engg. and inspections. Has had complete charge of elec. design and construction outside of New York City. Excellent references. D-502.

ELEC. CONSTRUCTION ENGR., E.E. Grad., 1928, 28, married. $3^1/_2$ yr. experience with large elec. contractor in estimating, design, control work and field supervision. Also 3 yr. experience in accounting, cost and stenographic work. Excellent references. Available immediately. D-46.

E.E., 33, with 10 yr. practical experience in elec. construction work on new bldgs. Familiar with all branches of elec. contracting including estimating, field engg. and purchasing. Have been in complete charge of elec. work in various large building projects in New York City. A-850.

Design and Development

E.E. GRAD., 35, single, mfg., maintenance, operation, designing experience. Inventions. Foreign languages. Desires responsible position with mfg. industry. (Development or production. Transformers; elec. locomotives; control, etc.) Location, immaterial; eastern preferred. D-452.

FORMER CORNELL INSTRUCTOR IN MACHINE DESIGN for 4 years. Allis-Chalmers designer and checker 5 years, M.E. and E.E. deg., shop apprenticeship and miscellaneous experience, 32, single. Desires teaching or engg. opportunity. Salary open. D-122.

DESIGN ENGR., col. grad., 38, married, citizen; 6 yr. elec. plant construction, wide experience all features design of pwr. and substations and industrial light and pwr., 3 yr. field experience as tester and supervisor. Desires position with utility, engg., or construction firm. Available immediately location, immaterial. D-482.

ELEC.-MECH. ENGR. with metallurgical knowledge. Col. grad. with post-graduate study, 30, married. Westinghouse design training. 6 yr. experience design elec. circuits and mechanical details of control apparatus, specialized in elevator equipment. Interested in alloy welding research. Location, immaterial. Available on short notice. C-9638.

E.E., GRAD., M.I.T. 1925, 30, married, 6 yr. utility design and engg. Capable complete elec. design steam, hydro station, high-, low-voltage

substations. Short circuit, relay studies large networks. Knows industrial control design. Available at once. Location not important. C-6366 322-C-5-San Francisco.

DESIGN ENGINEER, E.E. GRAD., 10 yr. power plant, d-c. rectifier substations, industrial and illumination experience. Expert draftsman, mathematician, knowledge of vacuum tubes, photocells, and their application in industry. Contributed many articles in engg. journals on original developments. East preferred, available immediately. B-7332.

E.E. GRAD., 45, married, G. E. Test and design experience; over 15 years' experience with larger companies in design and manufacture of transformers for special requirements, as well as standard lines. Desires position with utility or mfr. where experience will be valuable. Available on short notice. C-8806.

E.E. GRAD., 1930, 23, single, cooperative experience. 3 yr. with utility in central station design and construction. 1 yr. designing automatic pumping installations, floodlighting and general lighting, carrying full responsibility for all designs. Available immediately. Location, East preferred. D-561.

E. E. GRAD., 27, married. 5 yr. experience elec. and mech. design motors, fractional hp. to 500 hp. a-c. and d-c. 1 yr. experience substation and transmission line design. Grad. radio school. Thoroughly familiar with mfg. problems. Capable of assuming responsibilities of design. Nationally known references. Location, immaterial. Available immediately. D-565.

E.E. GRAD., 29, single, 2 yr. additional study in accounting. 5 yr. experience elec. and mech. design and development of fans and small motors with leading mfr. Desires position with mfg., utility or engg. concern or teaching elec., mech. drawing. Location, East. D-580.

ELEC. AND MECH. DESIGN ENGR., 48, E.E. grad., LL.B. and attorney at law. Power houses, substations and gen. steel mill engg. with special training in legal work connected with industrial concerns. Available at once. Preferred location, Ohio or Pittsburgh district. D-589.

E.E., 38, single. 13 yr. experience in design of mchy., apparatus, substations, hydro and steam pwr. plants with well known concerns, $6^1/_2$ yr. in last position. Desires connection with concern where ability and adaptability will lead to advancement. C-347.

Executives

CONSTRUCTION: ASSOC. E. E., 32, 16 yr. practical experience, elec. construction on new bldg. and repair work, familiar with all branches of elec. contract work including estimating, engg., purchasing, and inspection. 10 yr. in charge of elec. contract dept. for an elec. contractor. Location, immaterial. Available immediately. Salary open. D-478.

E.E. GRAD., married, 23 yr. experience in engg. and exec. capacities in industrial plants covering design, layout, contracting and purchasing of mfg. equip. and power plants including mech., elec., refrigerating, air-conditioning, and new processes for soap, drug, candy food products, and textile plants. D-488.

E.E., B.S. M.S. deg. 45, experienced in utility and industrial applications. Permanent position desired. D-498.

E.E. GRAD., 35, married. 5 yr. experience in system operating planning with utility, also sales, construction and some elec. maintenance experience. Past 2 yr. as design engr. with large elec. mfg. company. Can become valuable in any position. Exec. desired. Available now. Location, immaterial. B-7827.

GRAD. E.E., professional engr. license N. Y. State, 10 yr. experience elec. pwr. plants, substations, distribution, lighting, industrial installations, and specifications, wishes connection with firm which can use man possessing cnief characteristics as: Speed, thoroughness, willingness to work hard, accuracy, energy. Part or full time. Excellent references. D-454.

GRAD. E.E., 32, single. 9 yr. design and construction of pwr. transmission lines, substations and distribution networks as engg. inspector, purchasing, expeditor, preparing estimates and writing specifications. Excellent references. Desires connection with holding or operating company, contractor or mfr. Available immediately. Location, immaterial. C-3564.

E.E. GRAD., 4 yr. experience, drafting, design, construction, and engg. of modern hydro and steam pwr. plants, substations and ry. electrification. $5^1/_2$ yr. with leading mfg. concern in engg. of automatic and manual switchgear equipment. Foreign languages. Desires position, utility, engg., mfg. or ry. concern. Location, immaterial. B-7938.

E.E. GRAD., 26, married. 5 yr. with engg. dept. of holding company until merger, full experience in design, supervision and construction of

ENGINEERING SOCIETIES EMPLOYMENT SERVICE

57 Post St. San Francisco — 205 West Wacker Drive Chicago — 31 West 39th St. New York

MAINTAINED by the national societies of civil, mining, mechanical, and electrical engineers, in cooperation with the Western Society of Engineers, Chicago, and the Engineers' Club of San Francisco. An inquiry addressed to any of the three offices will bring full information concerning the services of this bureau.

Men Available.—Brief announcements will be published without charge; repeated only upon specific request and after one month's interval. Names and records remain on file for three months; renewable upon request. Send announcements direct to Employment Service, 31 West 39th Street, New York, N. Y., to arrive not later than the fifteenth of the month.

Opportunities.—A weekly bulletin of engineering positions open is available to members of the cooperating societies at a subscription of $3 per quarter or $10 per annum, payable in advance.

Voluntary Contributions.—Members benefiting through this service are invited to assist in its furtherance by personal contributions made within 30 days after placement on the basis of 1.5 per cent of the first year's salary.

Answers to Announcements.—Address the key number indicated in each case and mail to the New york office, with an extra two-cent stamp enclosed for forwarding.

substations and transmission lines. One year G. E. Test. Licensed electrician. Knowledge of radio testing and servicing equip. Available immediately. D-568.

E.E., 36, family. 15 yr. with engg. organizations: reports, designs, layouts, construction, performance tests, contracts and purchase, large industrial plants, utility pwr. plants, substations and network distribution systems; executive experience. Registered in Pa. Unemployed. Prefers consulting, maintenance, design, sales work in East, but will consider any location. C-2570.

E.E., Univ. of Va., 1924, single, desires place requiring hard-working tech. engr. of genl. experience in engg. dept. of utilities and cable mfr. on transmission circuits, elec. measurement and equip., inductive coordination, and insulation and cables in particular. Will accept temporary position in U.S. to prove ability. C-2282.

E.E. GRAD., 37, married. 4 yr. design on motors, control, steam turbines and engines. 8 yr. production, development, experimental work on centrifugal pumps and air compressors, elec. control equip. B-6926.

E.E. AND ESTIMATOR, 26 yr. experience, estimating, supervising and engg. for contractors, engg. for architects, etc., would like position with elec. contractor. Best of references. East or South preferred. C-8460.

E.E. GRAD., 14 yr. experience utilities in valuation work, rate investigations, engg. pwr. plants, substations, transmission lines, including estimates, specifications, design. Experience covers short-circuit studies, stability analysis, investigations of systems for load conditions. Desires position holding or operating company, or engg. firm. Available immediately. C-9570.

E.E. GRAD., experienced in elec. pwr. field desires position with pwr. company or mfg. firm. Able to supervise drafting, construction, and maintenance. B-1923.

CHIEF E.E., 36, E.E. grad. Extensive experience charge of design, construction, operation, maintenance plant, substations, transmission, trolley, telephone lines; maintenance elec. rolling stock, steam train lighting, elec. drive, lighting equip. factories, shops, offices, etc. Record of rapid advancement. Good organized. Successful handling Latin-American labor. Speaks Spanish. School grounding in French. C-9557.

E.E., experienced in load forecasting for economical planning for future growth. Established methods and records for systematic handling of estimates on property including 300 communities. Familiar with unit costs, estimates, and budgeting. Also experienced in elec. planning, design, and construction of transmission, substations and distribution. B-2876.

TECH. GRAD., married, 38, with $11^1/_2$ yr. experience as distribution, field and office engr.; $4^1/_2$ yr. tests, shop and construction work; desires position in engg. or operating dept. of utility. Location, immaterial. Available immediately. B-9248.

Instruction

GRAD. E.E., 1929; M.S. deg. 1931, Ohio State Univ. Ph.D. requirements partially completed. Experience in the fields of telephony, acoustics, and ry. signalling. Desires engg. or teaching position. Location, immaterial. D-475.

GRAD.; E.E., M.I.T., 35, married. 6 yr. industrial and teaching experience in E.E. Several years private research and development work on own initiative. Good ability, integrity, and personality. Desires position for life work. Location preferred, Middle West or South. C-2826.

ENGINEER-INSTRUCTOR; B.S., M.A.; 36, married. Desires college teaching connection. Teaching and lecturing experience, 10 yr. research and radio experience. Can teach E.E., radio, and physics. Available in fall or summer. C-1087.

PROF. OF E.E., B.S., and E.E. deg. 41, 6 yr. successful experience teaching practically all branches of E.E., state school. Considerable experience power, telephone work. 1 yr. switchboard engg. dept. Westinghouse. Available school year 1932–33. C-5021.

E.E. GRAD., 33, married. $3^1/_2$ yr. service engr. on pwr. and industrial apparatus and control. 2 yr. instructor in E.E. at state univ. 2 yr. transformer design and genl. engg. 1 yr. pwr. and substation construction. Desire engg. opportunity or teaching. C-1073.

E.E. PROF., B.S., and E.E., 33, married. $2^1/_2$ yr. G.E. Co., 5 yr. with utility, 4 yr. teaching, 1 yr. as acting head of dept. Desires change. Location, South or Middle West preferred. C-7152.

ASST. PROF. E.E., leading tech. col. of East, desires position, industrial concern where knowledge and experience gained in 14 yr. teaching fundamental courses in E.E. can be utilized in development, research, construction. M.I.T. graduate, married, 35, perfect health. Interested especially, elec. measurements, measuring instruments. Experienced draftsman, checker. D-581.

Maintenance and Operation

E.E., GRAD., married, 28; wide experience in industrial plant elec. construction and maintenance; ry. electrification; pwr. plant design, estimating, and supervistory construction experience with elec. contractor; cost analysis. Desires position with future. C-4428.

E.E. GRAD., 1928, 6 yr. hydro and steam plant elec. operation and maintenance, 5 yr. office and cost accounting. Would desire position with utility or mfg. concern in any part of U. S. or foreign. Salary secondary to opportunity. C-7796.

Junior Engineers

E.E., 28, married. Experienced in capacity of load dispatcher of pwr. Co., having interconnections with other companies. 6 yr. college work, including business training. D-468.

GRAD. E.E. 1931, Rensselaer Poly. Inst., single, 23. Desires position with any reliable engg. firm with opportunity for advancement. Salary immaterial. Wide engg. training. Best of references. Location, Eastern preferred or will consider any location. Available immediately. D-470.

E.E. GRAD., 1929, 26, single. 3 yr. experience in oil burner control equip. $1^1/_2$ yr. head of experimental test dept. of large mfr. of automatic heat control equip. Location preferred, Middle West. Available at once. D-486.

E.E. GRAD., 1931, single, 22. Experience in drafting and design of switches and pwr. distribution panels. Desires position in utility service and transmission of pwr. Also interested in research in the various branches of physics. Location, immaterial. Available immediately. D-471.

E.E. GRAD., 1929, M.S. 1931, leading univ., 18 months G.E. Test, 23, single. Desires to teach in tech. univ. Prefers Mid-West. C-9320.

E.E. GRAD., 22, 10 months' experience on construction. Desires employment with utility, engg.,

or mfg. concern. References furnished. Available with short notice. C-9885.

E.E. GRAD., 24. 3 yr. experience in industrial installation and control. Dull experienced with a-c. or d-c. elec. automatic drives and control. Desires position with utility or mfg. concern. Location, immaterial. Available on month's notice. C-8763.

GRAD. E.E., Univ. of North Carolina, 1931, 22, single. Extra study liberal arts and commerce schools. Desires position any engg. field, preferably telephone work. Four summers experience, Ill. Bell Telephone Co., installation and maintenance. Salary immaterial at start. Any location, foreign or U.S. Available immediately. D-527.

E.E. GRAD., 1931, 25, single, cooperative college. Limited experience with battery mfg. concern. Desires position with a future. Salary and location secondary. Available at once. D-534.

JUNIOR PHYSICIST experienced in X-rays, spectroscopy and elec. measurements available for research lab. or instructorship. M.S., Purdue, 1932. Speaking and reading knowledge of German and Spanish. At present asst. in physics. Available July. C-7387.

ELECTROCHEMICAL ENGR., 26, single. B.S. in E.E. and Ch.E. 3 yr. experience as field service engr., recording and controlling instruments. Also some sales. Refrigeration, time study and industrial engg. training. D-507.

GRAD. E. E., 1931, 24, specialized in hydraulics. Has had experience in large hydro plant. Desires position in the elec. industry. Location, immaterial. Available immediately. D-543.

E.E. GRAD., 1929; 27. 2 yr. on test floor of Westinghouse; also knowledge of radio and sound reproducing equip. Will accept small salary. Location, immaterial. Available now. D-542.

JR. ENGR., 22, single, 1932 grad. Desires position in elec. industry, preferable radio or one of its affiliated branches. Licensed radio operator. Salary secondary to opportunity. Available on short notice. Location, U.S. or foreign. D-544-323-C-1-San Francisco

GRAD. E.E., 1929, single, 23. 15 months student engr. on G.E. Test. Some test, drafting, and switchboard construction experience before graduation. Interested in position with concern doing consulting or construction work or with utility or mfr. Available at once. Location, anywhere in U.S. but New England preferred. C-8028.

E.E., Cornell Univ., 1931, E.E. deg., single, 22. Holds limited broadcast operator's license. Desires position in any elec. engg. field. Available immediately. D-519.

E.E. GRAD., 1931 M.I.T. (communications), 23, single. Radio experimenter for 10 years. Experience in radio repairing. Desires employment preferably in research or design work with radio, elec. instrument, television, or sound concern. East preferred, but elsewhere considered. Salary secondary. Available on short notice. D-553.

E.E., GRAD. 1929, 25, single, Phi Kappa Phi. 11 months, G.E. Test followed by 2 yr. on G.E. switchgear engg. covering application, development, testing, specifications, field servicing. Good scholastic and efficiency record. Desires connection with utility or engg. corp. Willing to start at bottom. U.S. or foreign. D-560.

E.E. GRAD., 1931, Univ. of Wash., 22, single. Will accept any position, any location. Research preferred. Good scholastic record. D-569.

GRAD. E.E., Stanford Univ., single, 24, desires connection with utility, sound picture industry, or radio mfg. firm. Experienced in genl. office work. Good draftsman. Location, immaterial. D-571.

E.E. GRAD., 1931, midwestern col., single, 24, American. Excellent scholastic record. Desires teaching opportunity. Will teach E.E., mathematics or mechanics. Location, immaterial. D-570.

E.E. GRAD., 1930, 23, single, 15 months on G. E. Test giving test experience with railway equipment, rectifiers, industrial apparatus, industrial control, and refrigeration developmental. Desires position with utility or mfg. concern. Available at once. D-409.

GRAD. E.E., 1931, midwestern col., 4, single. 3 yr. experience in genl. maintenance, construction and motor testing. Location, immaterial. Available at once. D-572.

E.E. GRAD., 1931, Lehigh Univ., 22, single. Summer experience with utility or industrial concern. Eastern states preferred, but other locations considered. Available at once. D-301.

E.E. GRAD., 1931 from Worcester Poly. Inst., member Sigma Xi, 22, single, desires connection with utility concern, industry, or with teaching, also interested in drafting. Location, immaterial. Available at once. D-228.

E.E. GRAD., Univ. of Pittsburgh, '31, cooperative col., single, 23. Westinghouse test and Bell Telephone experience. Desires many kind of engg. or engg. sales work in Eastern part of U.S. D-594.

E.E. GRAD., 1930, E.E., 1931, from Univ. of South Carolina, 23, single. 6 months' experience with South Carolina Pwr. Rate Investigating Committee. Able and willing to do practically any type of engg. work. Available immediately. Location, immaterial. Can give best of recommendations. D-595.

Research

RESEARCH AND PATENT ENGR. in radio and television field as well as in genl. elec. engg. seeks permanent connection with a stable organization. D-516.

E.E. GRAD., M.I.T., cooperative, 28, single, 4 yr. experience in planning section of large utility making transmission studies, field tests, and foreign wire relations. Wants connection with ry., utility, or mfr. anywhere in U.S. Available on short notice. D-536.

Sales

MANUFACTURERS AGT. OR SALES ENGR. Southern Calif., 48, 10 yr. engg. work, 12 yr. sales including 5 yr. South Am., good ability, integrity, personality, and knowledge of Spanish, used to pioneering and hard work, salary or commission, part or all time. B-9095.

Membership

Recommended for Transfer

The board of examiners, at its meeting held March 2, 1932, recommended the following members for transfer to the grade of membership indicated. Any objection to these transfers should be filed at once with the assistant national secretary.

To Grade of Member

Armstrong, Emerson A., mgr., pwr. sales, Pub. Serv. Co. of Northern Illinois, Chicago
Bunch, Charles H., secy.-treas., Acme Elec. & Mfg. Co., Cleveland, O.
Chatham, Clyde L., engr., Pub. Serv. Elec. & Gas Co., Newark, N.J.
Ebert Edward, Jr., asst. engr., Bklyn. Edison Co., Brooklyn, N.Y.
Grandy, Lewis S., assoc. prof. of elec. engg., Texas Tech. Col., Lubbock, Texas
Hauser, Oscar E., engr., meter dept., Detroit Edison Co., Mich.
Manby, A.W., supt., Chatts Falls Dev., Hydro. Pwr. Comm. of Ontario, Fitzroy Harbour, Ont.
Morrison, John W., ch. engr., Rochester Telephone Corp., N.Y.
Parmenter, Robert J., designing engr., Pub. Serv. Co. of Northern Illinois, Chicago
Pierce, Donald A., engr., inductive coordination Pub. Serv. Co. of Northern Illinois, Chicago
Schneider, Matthew S., operating engr., Union Gas & Elec. Co., Cincinnati, O.
Tarboux, Joseph G., prof. in charge of elec. engg. dept., Univ. of Tennessee, Knoxville

Applications for Election

Applications have been received by the secretary from the following candidates for election to membership in the Institute. Unless otherwise indicated, the applicant has applied for admission as an Associate. If the applicant has applied for direct admission to a grade higher than Associate, the grade follows immediately after the name. Any member objecting to the election of any of these candidates should so inform the assistant national secretary before April 30, 1932.

Andersen, A. W., University of Mich., Ann Arbor.
Armstrong, R. W., Elec. Installation Co., Boston, Mass.
Ballard, H. N., Puget Sound Pwr. & Lt. Co., Seattle, Wash.
Barrett, C. B., Western Elec. Co., Kearny, N. J.
Bateman, I. L., City of Los Angeles, Calif.
Beall, M. F., Univ. of Mich., Ann Arbor.
Bell, G. M., Canadian Westinghouse Co., Hamilton, Ont.
Beyer, N. S., Price Waterhouse & Co., San Francisco, Calif.
Bissell, C. H. (Member), Crouse-Hinds Co., Syracuse, N. Y.
Blackmon, H. N. (Member), Westinghouse Elec. & Mfg. Co., E. Pittsburgh, Pa.
Bugnion, F. E., 14 Clinton St., Cambridge, Mass.
Callicott, J. B., Pub. Service. Co. of No. Ill., Northbrook.
Caplow, A. I., 10010 Parkgate Ave., Cleveland, Ohio
Carlson, C. N., 264 Glenwood Ave., E. Orange, N. J.
Church, P. T., Kim Bean Co., Kim, Colo.
Clark, H. D., Conn. Lt. & Pwr. Co., New Britain.
Coe, J. C., War Dept., Wright Field, Dayton, Ohio
Cook, F. R., Westinghouse Elec. & Mfg. Co., E. Pittsburgh, Pa.
Craig, R. M., Hartford Steam Boiler Inspec. & Ins. Co., Pittsburgh, Pa.
Cramer, H. B., Brooklyn (N. Y.) Edison Co.
Dame, F. E., New York (N. Y.) Edison Co.
Dean, C. F., Chevrolet Motor Ohio Co., Toledo
Dee, T. C. (Member), 808 Third St., Jackson, Mich.
Devitt, W. E., Gen. Elec. Co., Schenectady, N. Y.
Dilley, B., Union Gas & Elec. Co., Columbia Park, Ohio
Dozer, H. E., Nat. Elec. Prod. Corp., Cleveland, Ohio
DuBois, W. R., DuBois Radio Serv., Mogadore, Ohio
Eggleston, L. A., Cornell Univ., Ithaca, N. Y.
Engster, F. W., Gen. Elec. Co., Schenectady, N. Y.
Ewald, G. A., Pub. Serv. Elec. & Gas Co., Newark, N. J.
Ferrin, A. J., 502 North Jackson, Pratt, Kans.
Fey, H. J., Univ. of Wash., Seattle.
Forbes, A. G., Fred Hall's Ranch, Eden, Tex.
Freeman, E. D., Okla. Gas & Elec. Co., Oklahoma City.
Frederiksen, V., Nat. Armature & Elec. Wks., Bluefield, W. Va.
Gaskins, D. W., Harry Alexander, Inc., Washington, D. C.
Gay, T. R., Standard Stations Inc., Pasadena, Calif.
Gierisch, W. C., Houston Ltg. & Pwr. Co., Texas
Goloff, M. J., Can. Westinghouse Co. Ltd., Hamilton, Ont.
Gomez-y-Gomez, T., 630 Terrace Place, Schenectady, N. Y.
Grant, C. A., 726 Univ. Ave., Syracuse, N. Y.
Grooms, A. O., Circuit Breaker Co., Columbus, Ohio
Haas, A. H., Brigham Sheet Gelatine Co., N. Y. City
Habich, C. A., Ewing Von Allmen Dairy Co., Cecilia, Ky.
Harrison, W. P., Okla. Gas & Elec. Co., Oklahoma City
Hartman, F. E., 2307 No. 40th St., Milwaukee, Wis.
Hartmann, C. S., Iowa State Col., Ames
Helfter, F. J., Pac. Tel. & Tel. Co., Santa Clara, Calif.
Heller, W. C., Commonwealth of Pa., Dept. of Labor & Industry, Harrisburg
Helwig, W. O., Speer Carbon Co., Milwaukee, Wis.
Henderson, J. T., Gen. Elec. Co., Schenectady, N. Y.
Hinde, E. J., Univ. of Wash., Seattle
Hoefer, E. G., Jr., 615 Park Place Dr., Chapel Hill, N. C.
Hoenie, N. J., Lincoln Elec. Co., Cleveland, Ohio
Hogg, R. T., Chicago Dist. Elec. Gen. Corp., South Chicago, Ill.
Holtz, C. F., New York Central R. R., N. Y. City
Hosselbarth, G. J., 1916 Himrod St., Bklyn., N. Y.
Hughes, J. S., Southern Bell Tel. & Tel. Co., Atlanta, Ga.
Ibach, W. R., The Milwaukee Elec. Ry. & Lt. Co., Wis.
Johnson, F. C., Stanford Univ., Stanford Univ., Calif.
Johnson, G. C., Mich. Bell Tell. Co., Detroit
Jones, E. R., Kansas City Pwr. & Lt. Co., Mo.
Kalachov, P. D., Univ. of Mich., Ann Arbor
Keachie, E. C., State of Calif., Los Angeles
Kennedy, E. F., Jr., 1624 E. 8th St., Des Moines, Iowa
Kiger, T. E., Mt. Airy, No. Car.
Knapp, D. A., Univ. of Calif., Berkeley
Knudson, C. M., Nevada Mass. Co., Mill City, Nevada
Koso, K. W., Kansas City Pwr. & Lt. Co., Mo.
Kriebel, W. K., Eastern State Penitentiary, Graterford, Pa.
Kullgren, G. V., Shell Petroleum Products, Loveland, Colo.
Lamm, R. H., E. Howard Clock Co., N. Y. City
Larson, L. J., Hexcel Radiator Co., Milwaukee, Wis.
Leeming, H. H., E. J. Cheney, N. Y. City
Leggett, F. E., 940 Jefferson Ave., Gainesville, Fla.
Lehikoinen, R., 380 South St., Fitchburg, Mass.
Levine, V. A., Brooklyn (N. Y.) Edison Co.
Lorenzen, L. M., Rockwell, Iowa
Luckert, A. A., 159 Russell St., Bklyn., N. Y.

McCartin, C., Barber Colman Co., Rockford, Ill.
McClavin, S. 1., Rochester Telephone Corp., N. Y.
McKinney, F. L., Southern Bell Tel. & Tel. Co., Ashland, Ky.
McKinney, J.E., Bell Tel. Co. of Can., Toronto, Ont.
McLean, W. H., Harvard Univ., Cambridge, Mass.
Metcalf, D. J., 2131-3rd Ave. West, Vancouver, B. C., Can.
Micka, T. J., Baker, Mont.
Mitchell, H. C. (Member), Brooklyn (N. Y.) Edison Co.
Moauro, J. S., 50 Cherry St., Springfield, Mass.
Moore, J. F., Univ. of Toronto, Ont., Can.
Morse, W. R., Univ. of Wash., Seattle
Murray, W. R., Univ. of Mich., Ann Arbor
Myers, R. R., Elec. Maintenance & Engg. Wks., Woonsocket, R. I.
Osterholtz, F. F., Westinghouse X-Ray Co., Inc., Cincinnati, Ohio
Paintin, E. L., Ill. Bell Tel. Co., Chicago
Palo, G. M., Puget Sound Pwr. & Lt. Co., Seattle, Wash.
Parrish, D. B., 9423-58th Ave. So., Seattle, Wash.
Pepall, J. R., Univ. of Toronto, Ont., Can.
Peterson, P., Gen. Control Corp., Minneapolis, Minn.
Peterson, R. M., Griswoldville, Mass.
Peterson, R. A., Route 4, Idaho Falls, Idaho
Peterson, S. R., Long-Bell Lumber Co., Longview, Wash.
Phelan, D. W., T. B. Kelley & Sons, Inc., Syracuse, N. Y.
Pieper, E. J., Van Horne, Iowa
Pokorney, H. F., 3 Sellwood Bldg., Duluth, Minn.
Pratt, E. J., Brooklyn (N. Y.) Edison Co.
Quigley, F., Am. Tel. & Tel. Co., Cleveland, Ohio
Rabuck, G. D., Pub. Serv. Co. of No. Ill., Chicago
Rahill, E. J., New York Tel. Co., Albany
Ramsey, W. S., Town of Morristown, N. J.
Reynolds, F. I., R. F. D. No. 2, Glens Falls, N. Y.
Rising, W. G., Colgate-Palmolive-Peet Co., Kansas City, Kans.
Rivera, J. J., 223 E. 126 St., N. Y. City
Rockefeller, R. W., Univ. of Michigan, Ann Arbor
Root, C. W., Scintilla Magneto Co., Sidney, N. Y.
Rudder, E. J , 714 W. Elm, Enid, Okla.
Rupp, R. H., Am. Tel. & Tel. Co., Cleveland, Ohio
Russell, E. H., 1437 Wyandotte Ave., Lakewood, Ohio
Samson, V. L., Univ. of Mich. Hospital, Ann Arbor
Sanning, F. G. Cincinnati & Suburban Bell Tel. Co., Cincinnati, Ohio
Sargent, H. C., Jr., Univ. of Wisconsin, Madison
Schaeffer, R., Okla. Gas & Elec. Co., Okla. City
Schmidt, F. L., New York (N. Y.) Steam Corp.
Schroeder, W., Univ. of Idaho, Moscow
Schwartz, P. W., Holland Furance Co., Columbus, Ohio
Schwennker, C. H., United Elec. Lt. & Pwr. Co., N. Y. City
Scott, G. G., Gen. Motors Corp., Detroit, Mich.
Scussell, J. J., 35 Gray St., Providence, R. I.
Segal, B., United Elec. Lt. & Pwr. Co. N. Y. City
Shelley, P. L., Okla. Gas & Elec. Co., Enid
Shepherd, S. G., Sask. Pwr. Comm., Shellbrook, Sask., Can.
Shiner, F. L., 6836 Montgall St., Kansas City, Mo.
Simon, G. E., Welda, Kans.
Sittel, V. J., Okla. Pipe Line Co., Muskogee
Sitz, E. L., Kansas State Col., Manhattan
Smith, C. A., 7 Oak Terrace, E. Lynn, Mass.
Smith, E. I., Western Union Tel. Co., Jacksonville, Fla.
Snoddy, B. L., Gen. Elec. Co., Butte, Mont.
Soutter, R., Jr., Okonite-Callender Co., Paterson, N. J.
Spahr, W. H., Metropolitan Life Ins. Co., N. Y. City
Stallman, A. C., Pub. Address System Installations, Ithaca, N. Y.
Stewart, C. F., U. S. Engrs., Catlettsburg, Ky.
Stokes, H. E., Pa. Central Lt. & Pwr. Co., Altoona
Stone, R. W., Oswego Motor Co., N. Y.
Takacs, G. J., Union Gas & Elec. Co., Cincinnati, Ohio
Teece, E. R., Saskatchewan Pwr. Comm., Regina, Sask., Can.
Teskey, C. H., Am. Tel. & Tel. Co., Cleveland, Ohio
Thomas, M. A., Consolidated Mining & Smelting Co., Trail, B. C., Can.
Thomas, T. R., Texas Agri. Dept., Austin
Thomas, W. S., Detroit Edison Co., Trenton, Mich.
Titus, H. W., Lux Fire Protection Equip., Bklyn, N. Y.
Van Aken, H. N., Union Switch & Sig. Co., Swissvale, Pa.
Waldron, C. J., Univ. of Ill., Urbana
Walker, H. H., 1106 Farnam St., Omaha, Neb.
Walters, T. R., Gen. Elec. Co., Pittsfield, Mass.
Wegner, E. A., Armour Inst. of Tech., Chicago, Ill.
Woodford, A. G., Allen Bradley Co., Milwaukee, Wis.
Wright, H. D., Pac. Gas & Elec. Co., San Francisco, Calif.
Zacherl, F. A., 128 Main St., Clarion, Pa.
Zwicker, F. W., Bethlehem Shipbuilding Corp., Quincy, Mass.
159 Domestic

Foreign

Bhadra, C. S., Messrs. C. Bhadra & Co.; Kusktea Elec. Sup. Co., Bengal, India
Griffin, W. S., Shanghai Pwr. Co., Shanghai, China
Johns, L., Victoria Falls & Transvaal Pwr. Co. Ltd., Vereeniging, So. Africa
Patel, B. J., B. B. & C. I. Rly., Bombay, India
Rao, C. V., Anglo-Persian Oil Co. Ltd., Abadan, Persia
5 Foreign

Engineering Literature

New Books In the Societies Library

Among the new books received at the Engineering Societies Library, New York, during February are the following which have been selected because of their possible interest to the electrical engineer. Unless otherwise specified, books listed have been presented gratis by the publishers. The Institute assumes no reponsibility for statements made in the following outlines, information for which is taken from the preface or text of the book in question.

Engineering Societies Library

29 West 39th Street, New York, N. Y.

MAINTAINED as a public reference library of engineering and the allied sciences, this library is a cooperative activity of the national societies of civil, electrical, mechanical, and mining engineers.

Resources of the library are available also to those unable to visit it in person. Lists of references, copies or translation of articles, and similar assistance may be obtained upon written application, subject only to charges sufficient to cover the cost of the work required.

A collection of modern technical books is available to any member residing in North America at a rental rate of five cents per day per volume, plus transportation charges.

Many other services are obtainable and an inquiry to the director of the library will bring information concerning them.

RAILROAD CONSTRUCTION, Theory and Practise. By W. L. Webb. 9th ed. N. Y., J. Wiley & Sons, 1932. 8x5 in., leath., $6.00. Pt. 1, 699 p.; Pt. 2, Tables, 226 p.—Deals with all phases of construction from the preliminary survey to the completion of the road and provision of the rolling stock. The present edition is largely new, the author having incorporated improved methods devised in recent years. Necessary mathematical tables are included.

MODERN DIESEL, a review of high speed compression ignition engines. London, Iliffe & Sons., Ltd., 1932. 142 p., 8x5 in., cloth, 2s 6d.—An elementary handbook on the origin, principles of construction, and its advantages. The principal types for automobiles, aircraft, and marine service are described briefly.

HUMAN ENGINEERING. By H. Myers. N. Y. & Lond., Harper Bros., 1932. 318 p., 8x6 in., cloth, $3.—The author, a physician, and management engineer, discusses the management, hygiene, and other topics pertaining to personnel problems.

HEAT ENGINES. By S. H. Moorfield and H. H. Winstanley. London, Edward Arnold & Co., 1931. 287 p., 8x5 in., cloth, $2.25.—An elementary textbook. Presenting the underlying principles clearly and concisely.

GRAPHIC STATICS. By S. Fairman and C. S. Cutshall. N. Y. & Lond., McGraw-Hill Book Co., 1932.—145 p. 9x6 in., cloth, $1.75.—The distinguishing feature is the grouping of three important topics in one volume. The book represents the course offered to engineering students at Purdue University.

ELEKTRISCHE HOCHLEISTUNGSÜBERTRAGUNG AUF WEITE ENTFERNUNG. By R. Rüdenberg. Berlin, J. Springer, 1932. 370 p., 9x6 in., cloth, 31.50 rm.—A series of lectures upon the problems of long distance power transmission, given under the auspices of the Electrical Engineering Society of Berlin and the Berlin Engineering University, by experts from the large electrical companies; discusses in a practical way the theory of a-c. transmission and of long lines, generators, and transformers, compensation, regulation, interconnection, breakdowns, and the economics of a-c. and d-c. transmission.

ECONOMICS OF PUBLIC UTILITIES. By L. R. Nash. 2nd ed. N. Y. & Lond., McGraw-Hill Book Co., 1931. 508 p., 9x6 in., cloth, $4.—To provide in one volume a comprehensive treatment of the underlying economic facts governing public utility considered as a business. Carefully revised and a chapter upon holding companies added. New material upon political activities and agitations against public utilities, legislation on interstate transportation, natural gas movements, and electric power transmission, also has been added.

COMMUNICATION ENGINEERING. By W. L. Everitt. N. Y. & Lond., McGraw-Hill Book Co., 1932. 567 p., 9x6 in., cloth, $5.—A text-book covering the fundamentals of communication by wire and wireless networks which aims to provide a balanced course stressing broad principles rather than specific applications. Author believes the work will be valuable also to the power field, as communication systems and power systems differ primarily in the complexity of their networks.

BEITRÄGE ZUR GESCHICHTE DER TECHNIK UND INDUSTRIE, V .21. Ed. by C. Matschoss. Berlin, VDI-Verlag, 1931–2. 188 p., 12x8 in., cloth, 10.80 rm.—The 21st volume of annual of engineering history; contains a number of valuable papers, a review of articles published elsewhere, reports on existing ancient engineering works and on museums of industry, and a bibliography of historical publications of the year. Essays on the discovery of magnetic induction development of electric heating during the nineteenth century, early knowledge of the magnetic compass, the development of reinforced concrete, and the history of hydraulic works in China.

MODERN MILLING OF SUGAR CANE. By F. Maxwell. Lond., Norman Rodger, 1931. 423 p., 10x8 in., cloth, 50s net.—A welcome addition to literature of sugar manufacture. Dr. Maxwell confines himself to the latter stage and presents an account of milling practise in the leading sugar-producing countries. The machinery used is freely described, including prime movers and such topics as electric drives, the operation of milling trains, and milling control.

COLOUR SCIENCE, Part 1. By W. Ostwald. Authorized translation with introduction and notes by J. S. Taylor. Lond., Winsor & Newton, Ltd., 1931. 141 p., 9x6 in., cloth, 15s.—This translation of the first part of "Farbkunde," treating of the theory and standardization of color, has been revised and supplemented by the author.

KINETICS OF HOMOGENEOUS GAS REACTIONS. (American Chemical Society Monograph Series.) By L. S. Kassel. N. Y., Chemical Catalog Co., 1932. 330 p., 9x6 in., cloth, $6.50.—This reviews critically, from a single point of view, information available upon the reaction kinetics of homogeneous gases. The subject is treated theoretically and experimentally in separate sections of the book. The theoretical treatment discusses the principles governing the rates of chemical reaction; the experimental part, all of the available data. Numerous references occur in footnotes.

HILFSBUCH FUR DEN TECHNISCHEN AUSSENHANDEL. By E. K. Lubowsky. Berlin, Hermann Wendt, 1931. 808 p., 10x7 in., cloth, 42 rm.—The purpose of this handbook is to enable the foreign representative of an exporter to anticipate fully the information which the home office must have before it can intelligently submit tenders for machinery or electrical equipment. 450 outlines are given covering various machines. The text is in English, German, French, and Spanish, fully indexed in each.

PLANNING PROBLEMS OF TOWN, CITY, AND REGION. Papers and discussions at the 23rd Natl. Conference on City Planning, Rochester, N. Y., June 22–24, 1931, publ. by Wm. F. Fell Co., Phila., 1931. 228 p., 9x6 in., cloth, $3.00.—Topics discussed are: Is city planning effective control of city growth? Mass transportation on city streets; master plans and official maps; zoning and administration; edges of zones; county planning; relation of special assessments; planning programs for small cities; prevention of blight adjacent to expressways.

RELAY HANDBOOK AND SUPPLEMENTS, 2 ed., 1931. Natl. Elec. Lt. Assn., N. Y. 1381 p., tables, 7x5 in., lea., $4.00 to members; $6.00 to non-members.—This new edition consists of a reprint of the handbook with a 367-page supplement and combined index, obtainable as a separate volume.

DIESEL REFERENCE GUIDE. By J. Rosenbloom originally announced in ELECTRICAL ENGINEERING, Jan. 1931, p. 76, now is available at $4 per copy instead of $10 as announced previously. Publishers agents: Rider Press, N. Y.

Industrial Notes

New Combination in Copper Field.—Effective March 21, the newly formed Phelps Dodge Copper Products Corporation took over and will operate the following fabricating units as divisions: the American Copper Products Division, with mills at Bayway, N. J., manufacturers of copper rods, bus bars, trolley wire, weather proof wire, etc.; The British American Tube Division, Bayway, N. J., condenser tubes, copper tubes, and pipe, etc.; Inca Manufacturing Division, Fort Wayne, Ind., enameled copper wire, coils, and magnet wires; P-M-G Metal Division, Bayway, N. J., copper and copper alloy products.

The Habirshaw Cable and Wire Corporation will maintain its separate corporate existence and will be operated as a subsidiary of Phelps Dodge Copper Products Corporation. With mills at Yonkers, N. Y., and Bridgeport, Conn., it manufactures rubber and lead covered copper wire, paper, and varnished cambric insulated power cables, and other electrical conductors.

The name of the present fabricating subsidiary, National Electric Products Corporation, will hereafter be the corporate title of the National Metal Molding Division of the company only, with headquarters at Pittsburgh. Its plant is at Ambridge, Pa., and the principal products are rigid and flexible steel conduits, metal molding, outlet boxes, etc. Wylie Brown is president of both the Phelps Dodge Copper Products Corporation and the Habirshaw Cable and Wire Corporation. Both companies have moved their offices and are now located at 40 Wall Street, New York. Through acquisition of the Calumet and Arizona Mining Company, and prior acquisition of the Nichols Copper Company and the National Electric Products Corporation, Phelps Dodge Corporation is one of the three large units in the copper industry in the United States.

New Disconnecting Link Boxes.—The G & W Electric Specialty Company, 7780 Dante Avenue, Chicago, has developed a new device for simple and economical sectionalization of high tension cables. It is an oil-filled, disconnecting link box, comprising an assembly of standardized parts, and is produced at low cost to meet individual requirements.

New Electrode for Welding Aluminum.—The Lincoln Electric Company, Cleveland, Ohio, announces a new electrode for welding aluminum which will be known as "Aluminweld." The new electrode is a 5 per cent silicon aluminum alloy; can be used for welding sheet or cast aluminum, and is designed for either metallic or carbon arc welding.

A New Vacuum Contact Relay.—The Ward Leonard Electric Company, Mount Vernon, New York, has added a vacuum contact relay to its line of midget relays. The vacuum contact element, which is actuated by the relay armature, is rated at 8 amperes intermittently and 6 amperes continuously at 220 volts. Relays equipped with this type of contact are especially applicable to operation in hazardous places and have a high rating, making them a heavy duty midget relay. These relays may be obtained for normally open or normally closed operation. Coils may be wound for 6 to 110 volts alternating or direct current.

A New Mercury Switch.—The CeCo Manufacturing Company, Inc., Providence, R. I., has formed an industrial division to develop electrical and electronic devices for industrial purposes. One of the products of this division is the "Mertact," a mercury electric switch. Mertacts are made in sizes from 1 to 100 ampere capacities. Sizable currents can be broken by a very small mechanical force, often eliminating the necessity of using intermediate relays. The new switch has a wide field of application in electric appliances, heating devices, automatic temperature control, and in equipment that requires frequent make and break of current. C. O. Cressy will be the engineer in the industrial division assigned to the application of this division's products.

Outdoor Switch Houses.—The Delta-Star Electric Company, Chicago, has developed a line of metal clad, outdoor switch houses for medium capacity distribution circuits. They are equipped with T.P.S.T. solenoid operated, trip-free oil breakers, rated 7.5 kv., 400 ampere interrupting capacity 30,000 kva. The circuit breakers are controlled from the switchboard substations. Space above the operating mechanism provides for instruments, relays, reclosing timer, control switch, etc., converting the units to full-automatic and self-contained if required. Front and rear doors give ready access to all parts for inspection. Manual, d-c. solenoid, a-c. and d-c. trip-free motor mechanisms are available. The houses are compact, well constructed, low in first cost and maintenance.

W. M. Bailey Now Chief Engineer of Dubilier Condenser Corp.—William Mason Bailey, formerly with the Wireless Specialty Apparatus Company, of Boston, has been appointed chief engineer of the Dubilier Condenser Corporation in New York City. In collaboration with William Dubilier and the engineering staff of the organization, Mr. Bailey has in large measure been responsible for recent Dubilier developments such as the standard unit oil condenser, the moulded micadon, the ultra high frequency capacitors and the improved electrolytic condensers.

Trade Literature

Illumination.—Bulletin 31F16, 8 pp., entitled, "Most Efficient Lighting for Schools and College." Holophane Company, Inc., 342 Madison Avenue, New York.

Electrical Sheets.—Bulletin, 12 pp. Describes "Armco" electrical sheet steel grades for motors, generators, and transformers. The American Rolling Mill Company, Middletown, Ohio.

Lead Tantalum Rectifiers.—Catalog TC-37, 16 pp. Describes Fansteel lead tantalum rectifiers for battery charging and direct-current power. Fansteel Products Company, Inc., North Chicago, Ill.

Belt Conveyors.—Booklet, 24 pp. An interesting, largely pictorial presentation of the use of belt conveyors for coal handling and transportation of raw materials in many fields. The Diamond Rubber Company, Inc., Akron, Ohio.

Motors.—Bulletin 174, 22 pp. Describes seven types of squirrel cage motors, including application tables, speed torque curves, and complete construction details. Wagner Electric Corporation, 6400 Plymouth Avenue, St. Louis, Mo.

Aluminum Alloys.—Booklet, 64 pp., "Alcoa Aluminum and Its Alloys." The book gives in concise form the physical and mechanical properties of the alloys produced by the Aluminum Company of America, Pittsburgh, Penna. Included are tables showing sizes of the basic commodities the company manufactures from these alloys.

Ventilating Propeller Fans.—Catalog, 48 pp. Describes Ilg self-cooled motor propeller fans. Contains numerous illustrations depicting applications in homes, garages, factories, etc. Ilg Electric Ventilating Company, 2850 No. Crawford Avenue, Chicago.

Monel Metal Bolts.—Bulletin T-1, 8 pp. A technical exposition of the properties of Monel Metal bolts which, among other applications, are extensively used in outdoor electrical installations because of their strength, ductility, and resistance to corrosion. International Nickel Company, Inc., 67 Wall Street, New York.

Self-Tapping and Drive Screws.—Catalog, 30 pp. Describes self-tapping screws, drive screws, and screw nails for joining and making fastenings to sheet metal, bakelite, slate, etc. Such screws are widely used in the assembly of radio receivers and by electrical manufacturers for fastening cleats and other wire devices, instruments, number plates, etc. to slate, ebony, asbestos, and other type switchboard panels. Parker-Kalon Corporation, 200 Varick Street, New York.